Evaluation

San Francisco Wastewater Master Plan March 1973

J.B. Gilbert & Associates
Sacramento

Metcalf & Eddy Inc.
Palo Alto

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EVALUATION SAN FRANCISCO WASTEWATER MASTER PLAN

MAY 1973

Prepared by
J. B. GILBERT & ASSOCIATES

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May 25, 1973

Mr. Robert C. Levy
City Engineer
Bureau of Engineering
Department of Public Works
City & County of San Francisco
351 City Hall
San Francisco, California 94102

Dear Mr. Levy:

SAN FRANCISCO WASTEWATER MASTER PLAN

We are pleased to transmit our evaluation of the Master Plan for Wastewater Management for the City and County of San Francisco.

In carrying out our evaluation of the Master Plan, we reviewed the City's wastewater management practices. San Francisco is the only city in California that is served totally by a combined sewer system that transports domestic and industrial wastes as well as stormwaters. Combined sewer systems like that of San Francisco are common only in older cities and used by approximately ten percent of the country's population.

The treatment provided dry weather flows at the City's three existing plants, although improved the past year, is inadequate to protect the aquatic environment--particularly when primary treated effluent is discharged to San Francisco Bay. When it rains, untreated waste is bypassed at 41 overflow structures located throughout the perimeter of the City. As a result, fecal material and grease are deposited on the beaches and shoreline waters are contaminated during winter months--occasionally at times of the year when the beach areas are heavily used. It is anticipated that the State and Federal regulatory agencies will become more insistent that these problems be resolved.

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We found the 1971 Master Plan to be the most economical alternative to resolve water quality problems. In our evaluation, consideration was given to reclamation and reuse of wastewaters. Reuse of a significant portion of the wastewater from San Francisco does not appear feasible within the foreseeable future due to the large volume of waste generated during winter months when water needs are minimal, the high salinity of the waste, and the lack of demand for reclaimed water in the area. Nonetheless, the Master Plan provides maximum flexibility to allow reclamation if potentials are found at a later date.

The 1971 Master Plan is basically sound and has been developed into a staged program of improvement which places highest priority on resolving the water quality problems. The few remaining questions can be resolved as design proceeds and should not delay the program. Recommended Phase I facilities and their capital costs are as follows:

1.	Construct a pipeline to transmit dry weather raw waste from the North Point service area to the Southeast wastewater treatment plant.	$24 million
2.	Upgrade and expand the Southeast plant to provide secondary treatment for dry weather flows from the North Point and Southeast service areas.	$92 million
3.	Improve the Southeast outfall and discharge treated effluent into San Francisco Bay.	$ 7 million
4.	Upgrade the Richmond-Sunset wastewater treatment plant to produce an effluent which will comply with the State's Ocean Plan.	$13 million

5.	Construct the transportation system from the Richmond-Sunset plant to the Southwest area of the City.	$25 million
6.	Construct an outfall extending approximately two miles into the ocean from the Southwest area.	$30 million
7.	Convert the North Point plant into a wet weather treatment facility and construct three shoreline and two upstream retention basins and the necessary pipelines to transmit wastes tributary to the Aquatic Park, Marina, and Fisherman's Wharf areas into the North Point plant.	$38 million

This program will result in a complete operable system which can be constructed in sufficient time to comply with State and Federal requirements for secondary treatment of dry weather flows. Bypassing of untreated waste to the North Shore beaches will be virtually eliminated, and bypassing at the ocean beaches will be significantly reduced. The existing Richmond-Sunset discharge location will be changed; this will comply with the prohibition of discharge anticipated for the proposed area of special biological significance surrounding Seal Rock. The total capital cost of Phase I facilities is estimated at $229 million.

After Phase I, the remaining elements of the Master Plan include:

1. A crosstown tunnel from the North Point and Southeast drainage areas to the Lake Merced area.
2. A treatment plant (Southwest Water Pollution Control Plant) near Lake Merced to be used only during storm periods.

3. An extended ocean outfall.
4. Additional shoreline and upstream storage basins located as found necessary by further study at critical points in the system.
5. Pipelines and pump stations to interconnect all facilities.
6. A central control system to characterize rainfall and runoff and regulate withdrawal rates from all retention basins.

Once the entire Master Plan is completed, which is anticipated to be a minimum of twenty years under the most optimistic funding and construction scheduling, virtually all waste will be adequately treated and discharged to the ocean in a manner that will assure protection of marine resources. Bypassing will be eliminated to the degree found necessary for protection of the various shoreline areas of the City. The additional facilities to complete the Master Plan are estimated to cost $360 million to $750 million, depending upon the level of control selected for various areas of the City.

State and Federal grant funds presently are available to support a substantial portion of the Phase I construction costs; however, it is anticipated that grant availability will decline in the future. The extent of grant participation can be finally determined only by the State and Federal agencies after review of a grant application. The City has sufficient bonds authorized but unsold to provide the local share of Phase I facilities.

The City has proceeded with much work necessary to implement the Master Plan, and the Public Works Department's program to develop and refine the Master Plan is superior to that of any of the cities whose plans were reviewed during the evaluation. However, the following additional actions are recommended to assure early completion of Phase I and to finalize plans for remaining facilities:

1. Adopt the Master Plan as a concept to be refined and improved as additional information and technology become available.

2. Approve Phase I as a firm plan to be constructed at the earliest feasible date.

3. Provide the Regional Water Quality Control Board with a time schedule for implementation of the Master Plan including specific dates for completion of Phase I and dates for decisions regarding completion of remaining elements of the Plan.

4. Prepare a project report for 87½ percent grant participation for all Phase I facilities and submit the report to the State Water Resources Control Board.

5. Prepare an environmental impact report and other necessary documents for Phase I facilities to comply with all State and Federal grant regulations and submit the documents to the State to support the project report. (It may be possible to revise documents previously submitted to the Board.)

6. Prepare a continuing utility-type financial plan including all costs and revenues associated with wastewater management to determine the need for future service charges, bond sales, and revenue from other sources.

7. Prepare a detailed cost-effectiveness analysis for the wet weather facilities included within Phase I and a general cost-effectiveness analysis for all wet weather facilities included in the Master Plan to comply with Federal law and State grant conditions regarding grant eligibility of waste systems containing stormwaters.

8. Complete necessary oceanographic studies in the area of the proposed ocean outfall as outlined in "Water Quality Control Plan, Ocean Waters of California - Guidelines for Technical Reports and Monitoring Programs." Particular attention should be given to the characteristics and variability of ocean current patterns to permit final location of the discharge point and design of the ocean outfall. The study should emphasize the toxicity work necessary to satisfy the State Department of Fish and Game. (This work is under way but should be reviewed to assure that all necessary data will be provided.)

9. Proceed with permit applications to the necessary State and Federal agencies for construction of Phase I of the ocean outfall.

10. Complete analysis of discharge alternatives for Bay disposal of secondary treated effluent from the improved Southeast wastewater treatment plant. The analysis should include evaluation of environmental benefits and costs of discharging effluent to Islais Creek, disposal through the existing outfall, and construction of an improved Bay outfall. Consideration should be given to the advantages of a surface field and the temporary nature of the Bay discharge.

11. Define alternative improved treatment processes that may be employed at the Richmond-Sunset wastewater treatment plant to produce an effluent that will comply with the provisions of the State's Ocean Plan and Federal regulations.

12. Determine the preferred location and appropriate exterior features for retention basins included within Phase I to assure compatibility with land use plans. Consideration should be given to all possible multiple land uses including the possibility of providing local recreation or parking areas on retention basin surfaces as alternatives to construction in streets.

13. Proceed with final design and construction of one retention basin at the earliest possible date to provide information necessary for refinement, and hopefully simplification, of their internal design and operation.

14. Refine the design and operation of the central control system by implementing the studies previously outlined by the City.

15. Schedule further detailed evaluation of those elements of the Master Plan not included in Phase I. It is suggested that the evaluation commence July 1976 and be completed in July 1977 to assure against delay in constructing improvements after completion of Phase I. The evaluation should establish priorities for proceeding with the Master Plan considering the effectiveness of Phase I, water quality and environmental goals and regulations existing at that time, cost-effectiveness, and the availability of funds.

We have appreciated working with you and your staff and are hopeful that our suggestions will assist in building a wastewater management system that will protect and enhance the shoreline waters and eliminate the threat of damage to the Bay and Ocean environment.

Very truly yours,

J. B. GILBERT & ASSOCIATES

Jerome B. Gilbert
President

METCALF & EDDY, INC.

Russell C. Holt

Russell C. Holt
Regional Vice President

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SUMMARY

Figures and a brief description of existing facilities, the recommended first phase of the Master Plan, and the completed Master Plan are included at the beginning of the Summary. The text of the Summary then evaluates the City's September 15, 1971, Master Plan and supports the recommended plan.

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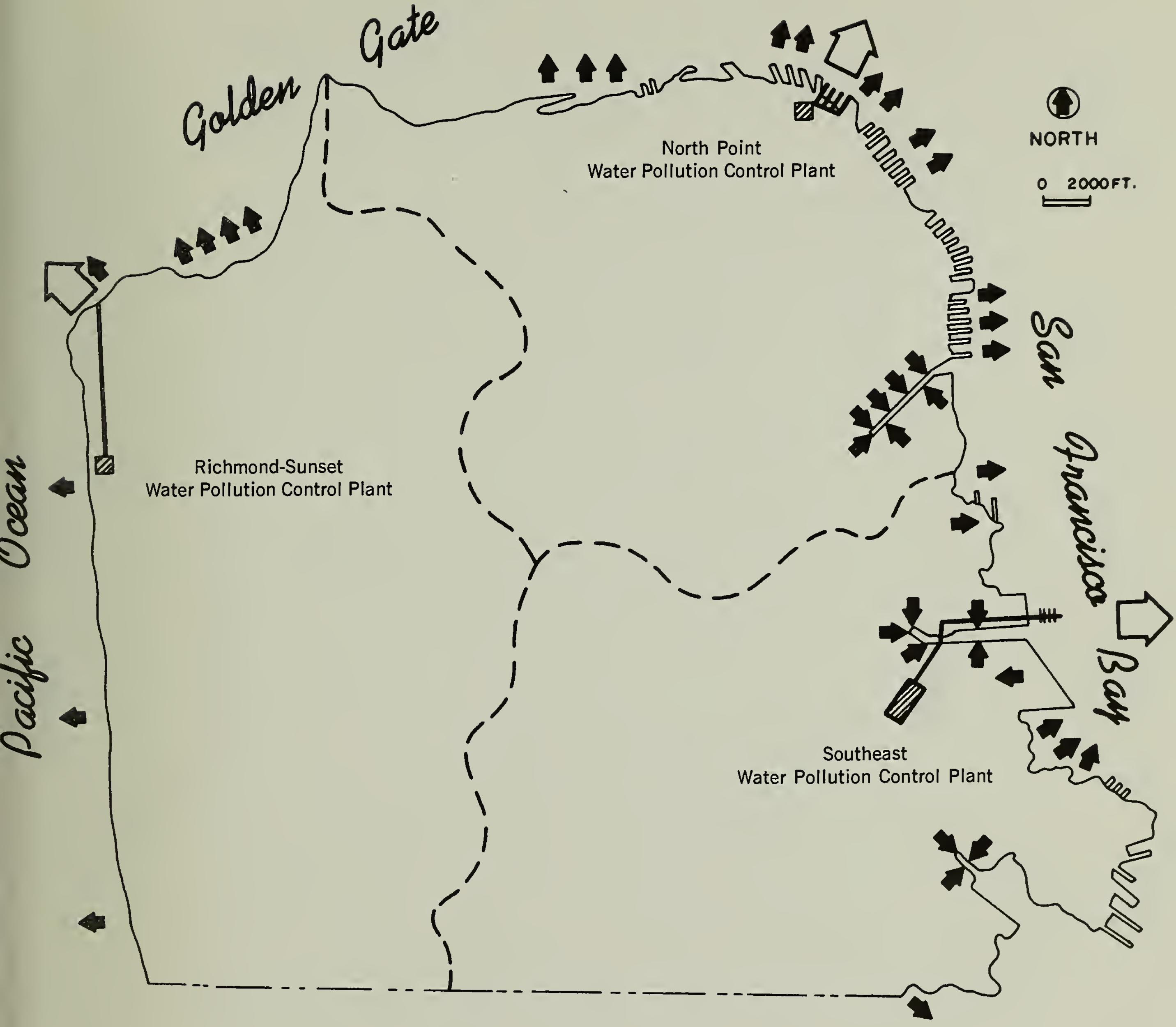
Figure 1

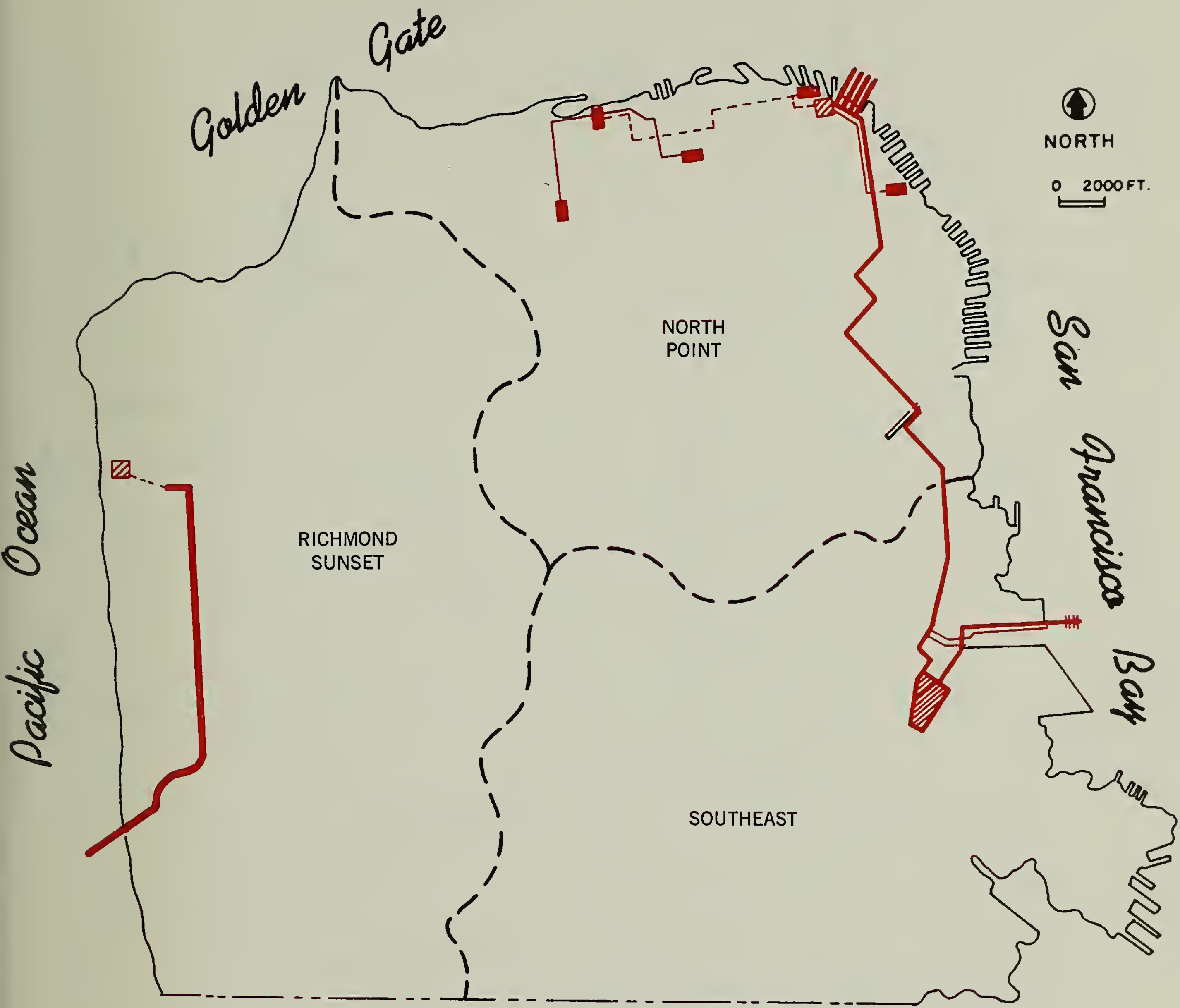
EXISTING FACILITIES



The existing three treatment plants (North Point, Southeast, and Richmond-Sunset) provide primary treatment with chemical addition and discharge through the outfalls shown on the map. Located around the perimeter of the City are solid arrows representing the existing 41 bypass locations. At these points a combination of untreated domestic wastewater and stormwater overflows into the Bay and Ocean when rainfall exceeds 0.02 inches per hour. Overflows occur approximately 80 times per year.

Figure 2

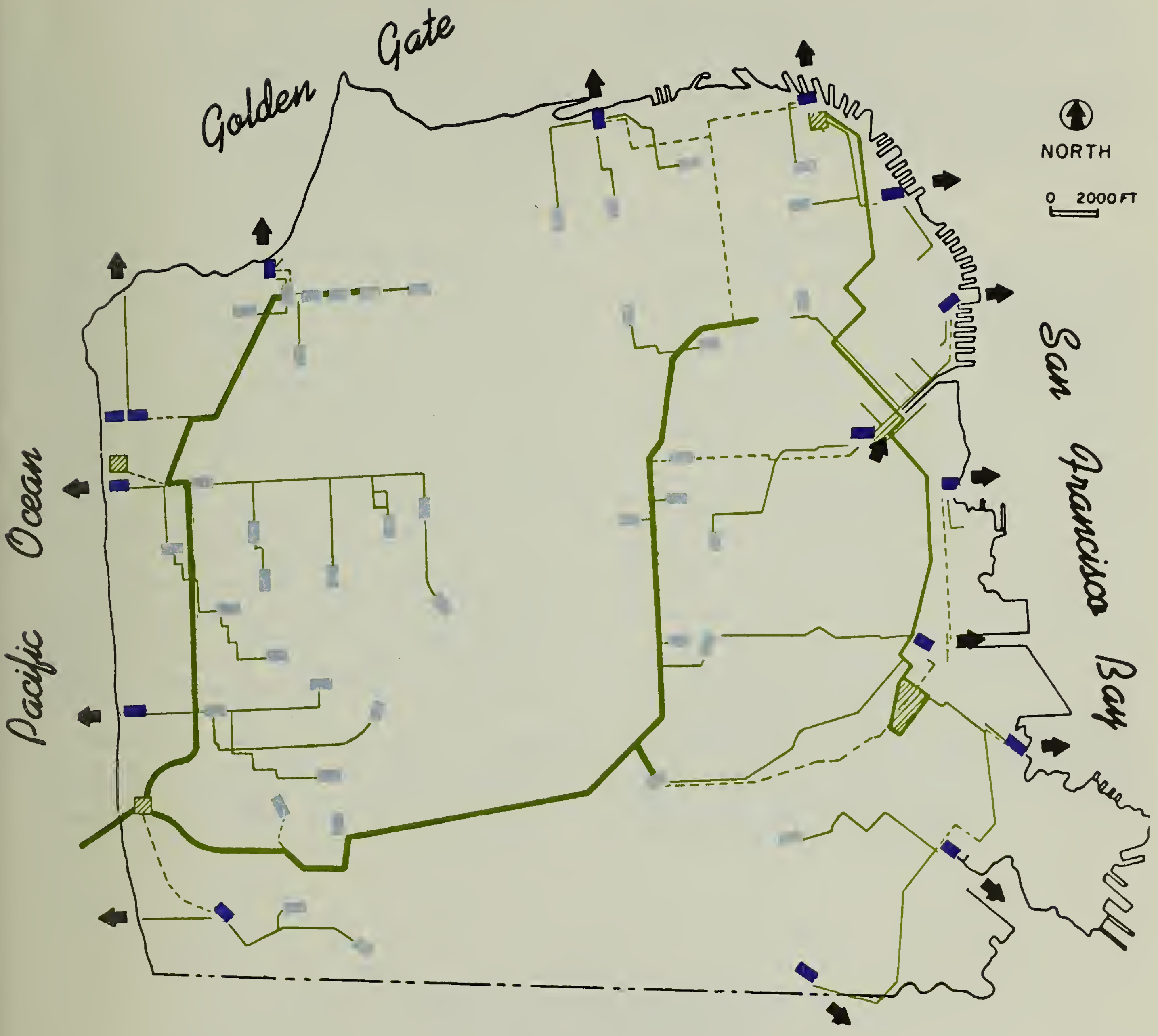
FIRST PHASE OF MASTER PLAN



The improvement program designed to achieve early compliance with State and Federal treatment standards and to reduce overflows in the critical north shore and ocean beach areas is shown in red. Raw waste from the North Point service area will be pumped to the Southeast Treatment Plant. The Southeast Plant will provide secondary treatment for the dry weather flows from the North Point and Southeast areas. The effluent will be discharged to the Bay through an improved outfall. Wet weather waste control facilities will be constructed to control overflows in the north shore area. The North Point Plant will be converted to a wet weather facility to treat wastewaters from the area during storm periods. The Richmond-Sunset wastwater treatment plant will be substantially improved to produce an effluent quality acceptable for continued ocean disposal. Effluent from the Richmond-Sunset Plant will be transmitted to the Lake Merced area for ocean disposal.

Figure 3

MASTER PLAN



The complete Master Plan for wastewater management is shown above. Retention basins (upstream — light blue, shoreline — dark blue) provide storage, control flooding, and allow regulation of flow to the transportation system (green). During the major portion of the year, wastes will receive secondary treatment at the Southeast and Richmond-Sunset plants. These treated effluents will be transmitted through the tunnel and pipeline systems to Lake Merced where they will be discharged approximately 4 miles offshore. The North Point Plant will be abandoned. During storm conditions, flows exceeding the capacity of the secondary treatment plants will be transported to a 1000 million-gallon-per-day capacity treatment plant at Lake Merced. The effluent will be discharged 2 miles offshore. The system will provide secondary treatment of all waste during a major part of the year and the bypassing of untreated waste will be virtually eliminated.

EXISTING WASTE MANAGEMENT PRACTICES

Combined Waste Collection Systems

The municipal and industrial wastewaters from San Francisco together with stormwater runoff are transported in a combined sewage collection system, most of which was constructed in the early 1900's. Such combined systems are no longer constructed but are common throughout the older cities in the United States and the world.

Seventy-six of the nation's largest cities have combined systems serving a total population of 20 million. Chicago, New York, Philadelphia, Detroit, Seattle, and Washington, D.C. all have large areas served by combined systems. The water pollution problems of those cities are similar to the problems of San Francisco but solutions differ due to topography, rainfall, waste, and water resources characteristics. Very few cities have constructed control facilities for management of the huge combined flows which occur during rains, but most are now developing plans for improvement.

Modern storm drainage is provided by completely independent systems that transport surface runoff directly to a watercourse. A second system of sanitary sewers conveys human and industrial wastes. The flow in separate sanitary sewers is relatively uniform compared with the large fluctuations in combined systems.

Sanitary and industrial sewage must be treated to prevent health hazards and damage to aquatic environments. Stormwaters, although they may contain large concentrations of pollutants, are not normally treated prior to discharge. The discharge of untreated combined sewage is a health hazard and is aesthetically unacceptable.

Despite these problems, combined flows from approximately 10 percent of the U.S. population are discharged untreated when the waste flow exceeds normal dry weather treatment capacity.

San Francisco's Existing Facilities

All but about 1 percent of the 24,000-acre area of San Francisco is served by a combined sewage system. During dry periods all waste is collected and treated at three separate treatment plants. When it rains, untreated waste is discharged from the collection system at 41 overflow structures located on the periphery of the City as shown on Figure 1.

The three plants provide advanced primary treatment consisting of chemical addition to gravity settling tanks for efficient solids removal. In each case, the effluent quality and treatment efficiency is superior to that of plain primary treatment, but not adequate to meet the present State requirements or the provisions of the 1972 Federal Water Pollution Act. Compliance with the regulations can be achieved only by major capital expenditures for new secondary treatment facilities.

A description of the treatment plants is given in Table 1 which shows hydraulic characteristics, Table 2 which summarizes data on effluent quality, and Table 3 which includes information on the effluent outfalls and waste field movement.

TABLE 1
HYDRAULIC CHARACTERISTICS
MILLION GALLONS PER DAY

	North Point	Richmond-Sunset	South East
Average Dry Weather Flow	65	21	19
Peak Hydraulic Capacity	200	70	70
Maximum Flow During Storm*	160	50	70

* The North Point and Richmond-Sunset Plants are not operated at capacity due to hydraulic limitations in the sewage transportation systems and plant headworks.

TABLE 2
EFFLUENT QUALITY CHARACTERISTICS

	North Point[1]		Richmond-Sunset[2]		Southeast[1]	
	mg/1	%Removal	mg/1	%Removal	mg/1	%Removal
BOD	101	47	138	32	81	56
COD	171				272	
Settleable Solids	0.01		0.25		0.13	
Suspended Solids	46	73.5	73	51	50	78
Grease & Oil	22		38	18	18	
Chromium	0.018				0.185	
Copper	0.084				0.08	
Lead	0.115				0.075	
Zinc	0.345				0.325	

[1] Average Values for November and December 1972

[2] Average values for October and November 1972

TABLE 3
DISPOSAL CHARACTERISTICS

	North Point	Richmond-Sunset	Southeast
Discharge Location	Underneath Piers 33 & 35 at Fisherman's Wharf	At Mile Rock	Extends from Pier 80 at Army Street Terminal
Outfall Length	800	Zero	500
Outfall Depth at Mean Low Water	10	1.3	40
Net Movement of Waste Field	Seaward in Contact with Shore	Southwest along Shoreline and Seaward	Into South San Francisco Bay

North Point Water Pollution Control Plant — The North Point plant is the largest, treating an average dry weather flow of approximately 65 mgd (million gallons per day) and a peak flow rate of 160 mgd during storms. The hydraulic capacity of 200 mgd is not utilized due to limited capacity of the waste collection system. After treatment, the waste is discharged 800 feet offshore at a depth of 10 feet through two outfalls located under Piers 33 and 35. Dilution of the waste by mixing with the receiving waters of approximately 3 parts receiving water to 1 part waste occurs immediately after discharge. The waste field remains on the surface adjacent to the shoreline and has a net movement (movement of the overall waste mass over a complete tidal cycle or longer) seaward through the Golden Gate.

In the past, the discharge has caused discoloration, floating particulates, and high bacteria concentrations in receiving waters. The recent improvements in treatment efficiency and the extension of the outfall, which is under design, will greatly reduce environmental and public health problems; however, compliance with State and Federal regulations cannot be achieved without secondary treatment or elimination of the discharge.

Richmond-Sunset Water Pollution Control Plant — The Richmond-Sunset plant currently treats an average dry weather flow of 21 mgd and a peak flow during storms of 50 mgd. The plant capacity of 70 mgd is not fully utilized due to the limited capacity of the transmission mains. The treated effluent is discharged just beneath the water surface at the shoreline near Mile Rock. Visual observations indicate a random movement of the waste field following shoreline currents after initial dilution in the surf area. The waste field normally appears as a visible brown discoloration in an area 100 feet in diameter or many times that size depending upon oceanic conditions. The waste field does not enter the Bay. High bacteria concentrations have been reported at times in the shoreline areas.

The waste field visibility and high shoreline bacteria concentrations, which are the only demonstrable environmental problems, can be corrected by disinfection improvements and extension of the outfall, or by changing the discharge location. Compliance with State and Federal regulations can be assured only by secondary treatment and modification of the discharge since the outfall is very near an area which likely will be designated by the State Water Resources Control Board as being of special biological significance. Discharges which would alter natural water quality conditions in areas so designated are prohibited.

Southeast Water Pollution Control Plant — The Southeast plant treats an average dry weather flow of approximately 19 mgd and has a peak hydraulic capacity of 70 mgd utilized during storms. The effluent is discharged into the Bay 500 feet from shore at a depth of 40 feet. Minimum initial dilution of dry weather flows is approximately 50 to 1. The waste field, which is generally submerged, moves with the tides back and forth across the discharge point. Concentrations of waste in the receiving waters therefore increase with each tidal cycle up to a maximum level.The initial dilution of 50 to 1 is misleading since a significant fraction of the diluting water consists of the waste discharged during previous tidal cycles.

The net movement of the waste field is into South Bay where water quality problems are more critical due to other discharges in the area and limited effective dilution water.

The discharge has caused discoloration, floating particulates, high bacteria concentrations, and other problems in the receiving waters. Improvement in the existing plant to provide secondary treatment would solve immediate problems. Due to the limited dilution, pollutant buildup in South Bay, and present water quality problems in the South Bay, it is likely that tertiary treatment or phasing out of discharges will eventually be required for a discharge from the southeast area into the Bay.

Operation During Storm Conditions

During storms when rainfall intensity exceeding 0.02 inches per hour (70 percent of all storm time), combined waste is bypassed. The waste contains varying amounts of human fecal material and grease solids ranging in size from particulates to several pounds. In winter months when bypassing occurs these floatable materials are found in nearshore waters and fecal sewage solids can be observed on the beaches. Swimming is quite limited but does occur at the ocean and bay beaches during the winter season; however, the beaches are used for hiking, picnicking, and general relaxation throughout the year.

When it rains the treatment plants are operated at less than full hydraulic capacity due to limited capacity of transmission system and maintenance problems at the plant headworks. Waste not entering the plants is bypassed through the 41 outflow structures directly to the Bay or Ocean.

Untreated waste is discharged only 2.4 percent of the time (Table 4) in an average year. These overflows affect water quality and beach conditions for days after each event and the 46 days when overflows occur leave traces of waste material on shoreline beaches throughout the winter months. An average of 82 overflow events occur each year.

TABLE 4

OVERFLOW FREQUENCY

Average Annual Number of Overflows	82 events
Average Annual Hours of Overflows	206 hours
Days Per Year Overflow Occurs	46 days
Percent of Time Overflow Occurs	2.4%

The average annual combined waste flow (Table 5) is 45 billion gallons with 13 percent, or 6 billion gallons, per year bypassed untreated.The bypassed waste includes 1.7 billion gallons of sanitary and industrial sewage.

TABLE 5

QUALITY OF SANITARY AND STORM WASTES BILLION GALLONS PER YEAR[BGY]

	Total	Treated		Bypassed	
	BGY	BGY	%	BGY	%
Sanitary	36.5	35.9	98.3	0.6	1.7
Storm	8.8	3.4	38.6	5.4	61.4
Combined	45.3	39.3	86.8	6.0	13.2

The quality characteristics of the bypassed waste (Table 6) are highly variable and dependent upon intensity, duration, and distribution of rainfall. The varying storm patterns result in the bypassed waste consisting at times of nearly all sanitary sewage or being characteristic of stormwaters. The quantity of solids in the bypassed waste is dependent upon the time interval between storms during which periods solids accumulate in the sewer system and collect on City surfaces. Early season storms following dry summer months flush out the sewers dislodging large particles of grease, wood, rags, paper, and other trash.

TABLE 6

QUALITY OF BYPASSED WASTEWATER [MG/L]

	Range of Storm Means	Mean	Range of Sample Values
BOD	10 - 254	49	2 - 480
COD	64 - 819	162	16 -12800
Suspended Solids	63 -1960	275	15 -5540
Settleable Solids (ml/1)	0.7- 71	3.9	0.1- 145
Grease & Oil	3.2- 109	26	0.1- 1330

The most objectionable characteristic of the bypassed waste is the fecal solids which are always present in significant quantities. The design of the 41 overflow structures is such that floatables, consisting of fecal material and grease, are bypassed first. Stormwater bypassing causes the shoreline waters surrounding San Francisco to be unsafe for swimming or shellfishing for most of the winter season.

The quantity, or mass emission, of pollutants in untreated bypasses (Table 7) is relatively small when compared to discharges from the existing treatment facilities. Protection of aquatic life, which is dependent upon the long-term, continual discharge of environmentally hazardous substances, can best be assured by additional treatment of dry weather flows.

TABLE 7

MASS EMISSIONS OF BYPASSED WASTE WATER
MILLION POUNDS/YEAR

	Treated Effluent	Bypassed Waste
BOD	36	2.5
COD	51	8
Suspended Solids	20	15
Grease & Oil	8	1.3

WASTEWATER MANAGEMENT CRITERIA

Goals and Objectives

San Francisco has been faced with a multitude of restrictions and regulations that are continually changing and to date, not precisely defined. Waste discharge requirements presently in effect for dry and wet weather discharges are not consistent with the provisions of 1972 Federal Water Pollution Control Act or recent changes in State law. Federal regulations adopted April 20, 1973 define the minimum required level of treatment as secondary for all Bay and Ocean discharges.

Despite these uncertainties, it is possible to define general master planning criteria based upon local needs, the new Federal law and regulations, and State plans and policies. Future Federal and State requirements can be accommodated in detailed planning and design of the treatment systems and outfall elements of the Master Plan as work proceeds.

Based upon environmental problems and present and anticipated policies and requirements of State and Federal regulatory agencies, the following goals and objectives are recommended for implementation of the San Francisco Master Plan. The objectives are listed in order of priority recognizing the magnitude of the problem and the need for a staged implementation program. Facilities should be scheduled for completion in accordance with these priorities.

Priority A — Protection of Aquatic Life (Fish and Shellfish must be protected by reducing the discharge of toxic substances, biostimulants and pathogens)

1 — Continuous waste discharges fully within the Bay should receive **secondary treatment [Southeast Plant].**

2 — Continuous waste discharges in the transition area between the Bay and the Ocean should receive **secondary treatment [North Point Plant].**

3 — Continuous waste discharges to the ocean should receive **secondary treatment [Richmond-Sunset Plant].**

4 — Continuous waste **discharges to the Bay should be eliminated [Southeast Plant].**

Priority B — Recreation and Aesthetic Enhancement (Shoreline waters and beaches must be free of fecal material, grease and pathogens. Waste fields must not be unsightly)

5 — Intermittent **bypassing** of untreated wastes that affect North **area beaches** should be virtually **eliminated.**

6 — Intermittent **bypassing** of untreated wastes that affect the **Ocean beaches** should be virtually **eliminated.**

7 — Intermittent **bypassing** of untreated wastes that affect the **East Shore Area** should be virtually **eliminated.**

8 — All waste **discharges to the Bay** should be **eliminated.**

Bay Versus Ocean Disposal

Effluent quality requirements for continuous Bay discharge are being upgraded and that trend is likely to continue. Wastes discharged in the Southeast area follow current patterns into South San Francisco Bay. Recent studies indicate that the South Bay is adversely affected by municipal discharges. Efficient dilution through tidal exchange and freshwater inflow is not available in the South Bay area. Tertiary treatment is likely to be required in the near future to control toxicity and nutrients in all South Bay discharges, even those as far north as the present Southeast plant discharge. It is possible that discharges will be discouraged or possibly prohibited to South Bay waters at some time in the future.

Secondary treatment will be required by the regulatory agencies for continued discharge at North Point. Tertiary treatment is not anticipated since very effective dilution can be achieved by an economical outfall structure. A surface field in this area has a net seaward movement whereas a submerged field moves into the Bay. A surface field discharged away from the shoreline will best protect public health and the aquatic environment.

Primary treatment will not be accepted for new or existing continuous ocean discharges. Secondary chemical or biological systems with efficient diffusion will provide environmental protection and be acceptable to the regulatory agencies for the foreseeable future. Ocean discharge is much preferred to Bay discharge to assure environmental protection and is likely more economical considering possible tertiary treatment requirements for Bay discharges.

Oceanic conditions in the proposed South west discharge area are highly variable due to the complex interrelationship of tides, currents, local weather conditions, and varying fresh water outflow from the Bay. The influence of the waste discharge will be nearly insignificant in comparison to the natural fluctuations. Nonethless, concern has been expressed for the health of the crab breeding areas, Studies have been conducted which strongly indicate that no environmental risk will result from the discharge. Due to the environmental and economic importance of crab resource, it is reasonable to continue the studies to provide a stronger basis for the final discharge decision.

Dry Weather Versus Wet Weather Control

The potential of damage to aquatic life from bypasses of untreated waste during storms is minor when compared to the continuous discharge of waste to the Bay from San Francisco and other communities and industries. Bypassing creates unacceptable aesthetic conditions on beaches and contaminates the shoreline waters for a major portion of the winter months.

State and Federal regulations require secondary treatment of continuous discharges and grant funds are available to help fund the necessary facilities. San Francisco is presently under cease and desist orders issued by the State that can be satisfied only by construction, without delay, of a system that will achieve secondary treatment of dry weather flows.

It can be anticipated that the regulatory agencies will require implementation of a corrective program requiring substantially complete elimination of untreated bypasses. Primary treatment, possibly with chemical addition, specifically designed to provide efficient removal of settleable and floatable solids is anticipated as being adequate for the high volume flows that occur during winter months.

In addition to primary treatment for wet weather flows, Bay disposal of wet weather discharges will likely require disinfection and dechlorination. Ocean discharge of wet weather flows should not require disinfection or dechlorination provided the effluent can be dispersed seaward. Oceanic characteristics would permit discharge without continuous disinfection, and its resultant toxicity, making ocean disposal much preferred to Bay discharge.

Wastewater Reclamation

The potential for reclamation and reuse is a major factor in determining the acceptability of the Master Plan. Reclamation must be considered if a reuse potential is available. Within the foreseeable future, the only major reuse potential is irrigation in the Sacramento-San Joaquin Valley or salinity control in the western delta or Suisun Marsh. A system for transportation of reclaimed water from the bay area to the Valley or delta including capacity for San Francisco waste would be extremely costly and cannot be anticipated for many years.

San Francisco's wastes are too high in total dissolved solids and chlorides for irrigation of any crops other than the heartiest grasses. Correction of this problem would require construction of an independent interceptor sewer to collect the waste generated in the higher elevations of San Francisco where sewers are not infiltrated by Bay waters.

The reuse potential for irrigation in or near San Francisco is quite limited. Approximately 10 million gallons per day (10 percent of the summer waste flow) could be utilized during summer months for irrigation of the major parks, golf courses, and cemetaries in the area. The major areas include Lincoln Park, Harding Park, Golden Gate Park, McLaren Park, and the cemetary in San Mateo County. Golden Gate Park presently utilizes 1 mgd of reclaimed water during summer months. Local advanced treatment systems could be used to meet this limited need. Such uses would not influence the general concept of the Master Plan since the potential reuse quantity is small and irrigation occurs in summer months only.

Throughout the Bay area, wastes generated locally exceed the local reuse potential. Therefore, transportation of San Francisco waste to another area near the Bay for reuse would eliminate the more economical alternative of reuse of locally generated wastes. There are no powerplants or other major industries in San Francisco where reclaimed water could be utilized for cooling purposes.

Municipal reuse in San Francisco and areas to the south on the peninsula is not considered feasible at this time. San Francisco's high quality fresh water supply is adequate to meet anticipated needs through 2020, and with reduced population growth rates that date will likely be extended. Although it is not desirable by today's standards, it may be feasible at some later date to store reclaimed water in or near Crystal Springs Reservoir for use in the south peninsula area where groundwater supplies are declining in quality. Such reuse would require change in the State Health Department's conservative attitude toward municipal reuse and development of more economical treatment systems.

The possibility of viable reclamation and reuse programs within the next several decades is therefore quite minimal — particularly for the high-rate, short-duration flows which occur during the winter months when virtually no reuse potential exists. It is essential, however, that the Master Plan be compatible with the future local and regional reuse potential to assure that reclamation alternatives are not precluded.

THE MASTER PLAN — AS PROPOSED SEPTEMBER 15, 1971

The Concept

The Proposed Master Plan (Figure 4) consists of one integrated system of transport, storage, treatment, and disposal facilities designed to provide the most cost-effective solution to waste management for San Francisco. The proposed Plan consists of the following elements:

Monitoring System —
A centrally monitored system of 32 rain gages and 120 sewer flow monitoring devices to measure storm intensity and runoff continuously as the storm approaches and traverses the City.

Combined Sewers —
Continued utilization of existing combined sanitary and storm sewers throughout the City with appropriate improvements and replacements.

Shoreline Storage —
Fifteen shoreline retention basins to consolidate the existing 41 overflow structures. These basins will receive waste from upstream areas and provide storage allowing withdrawal at controlled rates. Wastes from the 15 shoreline basins will be pumped into either the crosstown tunnel or the Oceanside transport system.

In-System Storage —
Upstream retention basins in many of the 15 watersheds. These upstream basins will permit regulation of flows to downstream sewers and the 15 shoreline retention basins thus reducing localized flooding during heavy rains and providing storage for later treatment.

Crosstown Tunnel —
A crosstown tunnel from the North Point drainage basin to the Southeast drainage area thence turning westward and terminating near Lake Merced. The tunnel will transport all stormwaters and municipal waste from the north and east portions of the City to the Lake Merced area for treatment and disposal.

Oceanside Transport —
An oceanside pipeline or tunnel from Golden Gate Park south to the Lake Merced area. This line will transport all waste from the west side of San Francisco to Lake Merced.

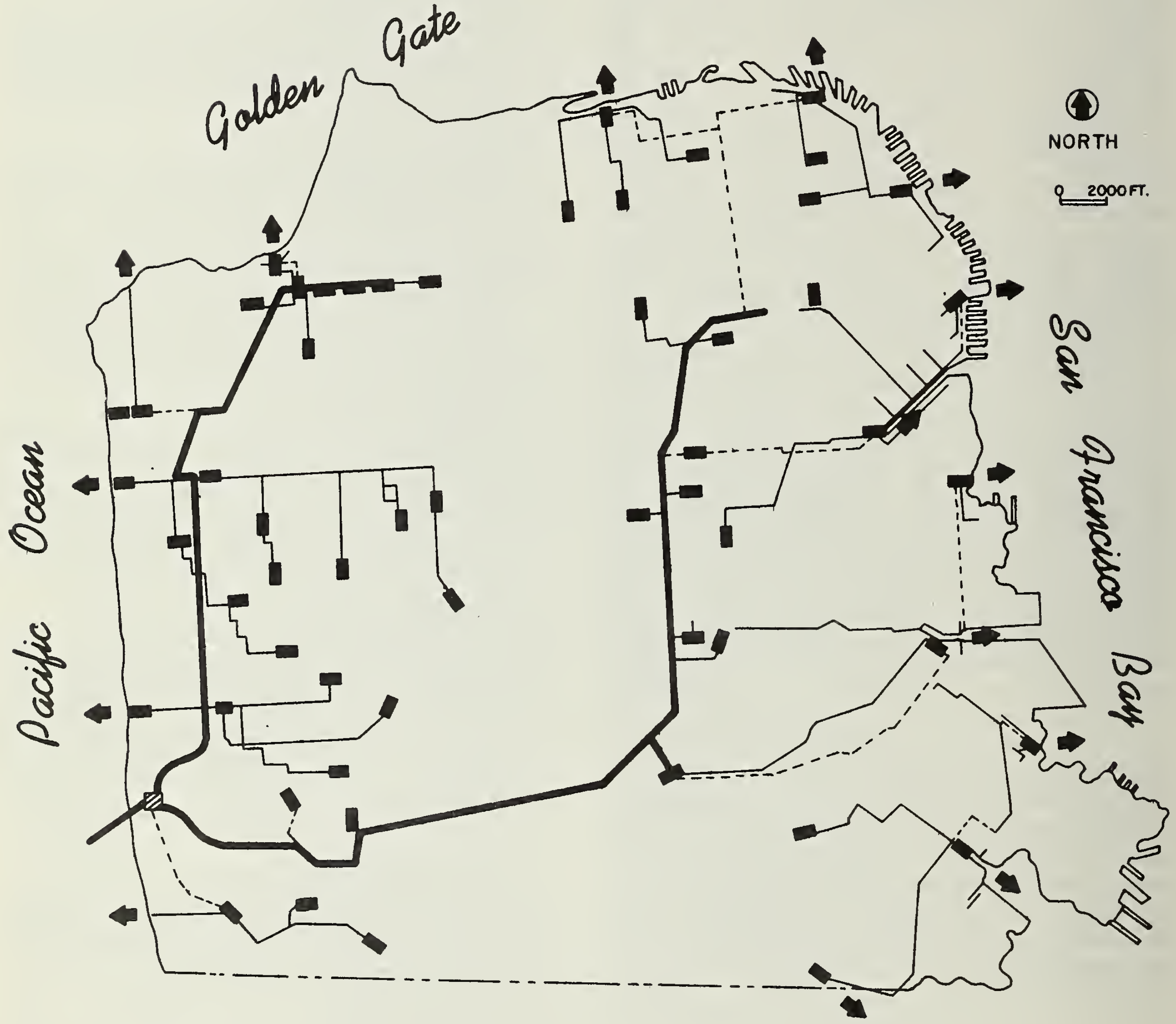
Tunnel Storage —
Storage Capacity associated with the Richmond-Sunset and crosstown tunnels to regulate flows from the transportation system into the treatment plant.

Southwest Treatment Plant —
One treatment plant located in the Southwest portion of the City near Lake Merced for the combined sanitary and storm flows designed to provide secondary treatment of the continuous dry weather waste flows and primary treatment for the intermittent storm flows.

Figure 4

PROPOSED MASTER PLAN

[Sept. 15, 1971]



This figure shows the Master Plan as presented in the City's report dated Sept. 15, 1971.

Ocean Outfall —
A dual-purpose ocean outfall designed to transport the continuous dry weather flows four miles into the ocean and flows above the base rate two miles into the ocean.

Control System —
A centrally located system to control withdrawal rates from all storage facilities and achieve maximum utilization from available storage capacity to minimize bypassing, select bypass locations, and regulate flows into the treatment plant.

The Master Plan integrates treatment capacity, pumping rate, storage volume, and the transportation rate to allow future selection of the most cost-effective combination. Alternative storage, transportation, and treatment facility capacities are dependent upon a determination of an acceptable number of overflows for various areas of the city and the advantages of bypassing through an ocean outfall compared to bypassing at the shoreline.

System Operation

During dry weather conditions, sewage would be collected and transported through the system to the Southwest secondary treatment plant with a peak capacity of 250 million gallons per day and discharged through the four-mile ocean outfall. Storm flows utilize the same system except that these may be stored in the retention basins and tunnel system and withdrawn at selected rates for transport to the Southwest plant.

When rainfall occurs, the storm intensity and runoff rates are measured by rain gages and sewer flow meters located throughout the system. Data are continually transmitted to the central monitoring station. Waste volume in storage, storage withdrawal rates, and transport rates are centrally controlled for each retention basin based upon the spatial and temporal runoff characteristics of the particular storm. Should both the storage volume and transport capacity from any of the 15 shoreline retention basins be exceeded, overflow will occur from the basins to the nearest receiving water. The frequency of overflow is dependent upon the capacity of storage and transportation facilities serving that particular area.

Waste Treatment and Disposal

To assure adaptability to various waste flow rates and changing quality, the Southwest treatment plant is designed as a split-flow facility. The plant can be readily expanded in capacity or modified for more advanced treatment processes if needed. Waste flow during dry weather and up to 250 mgd during storms will receive secondary treatment. During wet weather, flow above 250 mgd and up to 1,000 mgd will receive primary treatment with chemical precipitation. The effluents are then blended prior to discharge.

The outfall will transport 250 mgd four miles from shore to a depth of 80 feet producing a submerged field. Flows above 250 mgd are discharged two miles from shore through the same pipeline to a depth of approximately 30 feet producing a surface field. The total outfall capacity is 1,000 mgd.

Storage

Four storage alternatives are available. The final selection will be based on the desired results and available funds. The four alternatives provide citywide storage capacities of 9, 18, 33, and 56 million cubic feet. The major transport facilities are sized at 0.3 inches per hour rainfall from the tributary area with a maximum capacity of 1,000 mgd. Transportation rates from the individual retention basins will be established following analysis of the rainfall data presently being collected.

System Control

A centrally located computer system will be utilized for control of the Master Plan elements. The rain gages and sewer flow measuring devices will continuously transmit data on storm and runoff characteristics to the operations control center. Signals will be sent to the retention basins and pump stations to regulate storage and transmission rates from each watershed of the City recognizing the spatial and temporal characteristics of the rainfall and achieving maximum benefit from available storage.

MASTER PLAN EVALUATION

The Concept

The Master Plan concept is far-reaching in its goals and logically structured in its development. It is an aggregate of many complex elements each dependent upon engineering judgements, priorities, and data analyses designed to operate as one integrated system.

Whereas many of the nation's largest cities are faced with similar problems of combined sewage overflows and inadequate treatment facilities, few have approached the problems in such depth and with the high degree of expertise gathered and applied by the City of San Francisco. The level of control of water quality offered by the Master Plan equals or exceeds that offered by the available plans of other communities with similar problems and at a comparable cost.

The concept of one integrated system which utilizes storage, transportation, treatment, and disposal to achieve maximum benefit recognizing the variations in storm characteristics is very sound. Alternatives cannot accomplish similar goals at comparable costs.

Basic Alternatives

The obvious alternative would be to construct separate storm and sanitary systems. Separation of sewers would cost over $3 billion and result in major disruption throughout the City for many years. The water quality benefits which could be achieved by separation would be less than can be accomplished by the far more economical Master Plan, and if separation were achieved, some treatment or special disposal practices may still be needed due to the highly urban characteristics of the City which result in pollutants in the storm waters.

A second alternative concept would be to construct independent systems for each of the three major watersheds. The capital and maintenance and operation costs of this alternative are greater to accomplish a similar level of control. In addition, environmental protection would be less since ocean disposal is not easily achieved. Local sites, particularly at North Point and Richmond-Sunset, are not conducive to major expansion.

A third alternative could include separate treatment facilities for wastewaters bypassed during storms at the existing 41 overflow points or at some consolidation of those sites. The capital and maintenance and operation costs to achieve an acceptable level of control is estimated at $3 billion which far exceeds that of the Master Plan. The high cost is due to the large number of separate treatment facilities located throughout the City. Reliability of operation would be far less due to the seasonal use, long periods of shutdown, and need to "come on line" almost immediately at very high flow rates. High rate treatment systems for removal of floatables, solids, and pathogens have not been developed to provide and effluent quality satisfactory for discharge around the periphery of San Francisco, and environmental protection would be less due to continued Bay discharge.

These alternatives were appropriately rejected and further analysis of their cost or effectiveness is not warranted.

Master Plan Refinement Needs

Although design can proceed on the initial Phase I elements (see the recommended staging program, phase I) of the Master Plan, much work remains to refine the system particularly with regard to determining:

- The number, types, locations, and size of storage facilities to most effectively reduce overflows in the more heavily used beach areas recognizing that construction of the entire system will require an extended implementation period.
- The appropriate capacities for transportation of wastes from sources and storage facilities to points of ultimate treatment and disposal.
- The appropriate control system to provide the most efficient and reliable operation.
- The best way to maintain flexibility in the planning and construction of all facilities.
- The appropriate capacity and the most effective treatment process for wet weather treatment facilities.
- The wisest expenditure of City financial resources, coupled with assistance grants from Federal and State agencies, in staging construction of the system to provide maximum benefit at the earliest date and the greatest cost effectiveness as construction proceeds on the system.
- The aesthetic criteria for major works including storage facilities, pump stations, and the treatment plant to assure compatability with land use planning.
- Construction practices, locations, and routings for pipelines, tunnels, storage facilities, pump stations, and the treatment plant to minimize environmental impacts and disruption of local services.

Transportation System

The concept of one integrated transportation system is sound in that a common system can maximize advantage of spatial and temporal fluctuations in rainfall. The size of all elements of the transportation system has not been determined. This decision should be carefully made and critically evaluated prior to design.

Consolidation of Present Overflows — Transportation facilities for consolidation of the 41 overflows into the 15 shoreline retention basins are not precisely defined in the Master Plan Report; however, this information is now available. Problems of localized disruption during construction should be anticipated and minimized prior to final design. Element sizes should be based upon rainfall data now being gathered for each basin.

Transport from Storage to Tunnel — Sizing of transportation facilities is being completed on the basis of detailed rainfall data presently being collected. Prior to design the specific routes for force mains from the shoreline storage basins to the crosstown tunnel should be evaluated to minimize disruption of localized services and environmental problems.

Crosstown Tunnel — The crosstown tunnel from North Point to the Southwest plant site provides a logical solution to the transportation problem. Right-of-way problems are less with tunnel construction than with surface pipelines, disruption of utilities and disturbance of the public is minimized, and cost savings are realized.

Because of San Francisco's unique topography, the benefits of gravity flows have been incorporated into the design. Approximately one-half of the City is at elevation 50 or higher. The tunnel will start at this elevation and slope uniformly in its passage across the city to the Lake Merced treatment plant and the outfall sewer beyond. Thus a large portion of storm flows will require little or no pumping.

The tunnel in the Master Plan Report was initially sized for 0.1 inches per hour of rainfall from the tributary area which is equal to the treatment rate. The present City thinking is to size the tunnel for 0.3 inches per hour up to a maximum rate of 1,000 mgd. Indications are that the 0.3 inches per hour rate will provide adequate control and the necessary flexibility for future planning. This rate is exceeded on the average only 5 hours per year. The limitation of 1,000 mgd appears arbitrary at this time and should remain open pending analysis of the rainfall data.

By the summer of 1973, sufficient rainfall data will be available to proceed with final design of the tunnel if constructed as a simple, single tube transportation system sized to incorporate storage capacity. Sizing on the basis of 0.3 inches per hour rainfall in the tributary area with reductions in proportion to reductions in average rainfall density as the area increases, appears appropriate for transport sizing. Additional tunnel capacity for common storage is recommended.

Richmond-Sunset Transport — Construction of this transportation system may be either by open excavation or tunneling; however tunneling may be difficult due to sandy soil conditions. The size of the transportation system for the wastewater of the City will largely determine the number and volume of overflows of untreated combined waste to the ocean beaches. The system now under study by the city to serve this area is sized for 0.3 inches per hour rainfall on the tributary area with an upper limit of 1,000 mgd. Due to the relative proximity of the proposed Southwest outfall and the vast improvement offered by deep water discharge as opposed to releasing overflows on the beaches, it may be desirable to further increase this capacity. Here also consideration should be given to providing storage by simply increasing the size of the transportation system.

Storage Facilities—

Upstream Retention Basins

— Upstream storage basins can effectively retain peak conduit flows, provide retention for later treatment, relieve excessive loadings, and prevent flooding in areas of under-sized downstream sewers. The rainfall data presently being developed will determine appropriate locations, sizing, and numbers of these basins.

A prototype, full-scale, retention basin is proposed to be studied in a demonstration project where detailed analyses can be made of the control system, component cost, and hydraulic performance. This project is urgently needed as it will provide information necessary for final design. The proposed number of basins appears excessive and analysis should be made for each area in an attempt to achieve the same goals by a reduced number. The internal preliminary design appears unnecessarily complex. It may be possible to greatly simplify basin design which should be a major objective of the pilot plant studies.

Questions of compatibility with local land uses have not been resolved. Careful planning to locate basins and detailed design of visible and accessible portions is essential to assure that the basins are compatible with land use plans.

The six proposed sites of basins beneath street intersections will require considerable utility rerouting and maintenance of temporary services. Consideration should be given to offstreet sites where basins can be constructed integrally with public use facilities such as parking area, playgrounds, and parks to provide additional benefits to localized areas. Construction of a basin will likely result in six months to one year of major disruption. The generally assumed logic that disruption will be less with the basin than with replacement of the sewers appears correct where sewer replacement is necessary. Construction practices should be evaluated and construction criteria developed to assure minimum disruption.

Shoreline Retention Basins — Shoreline retention basins are necessary if overflows are to be prevented or significantly reduced. To be completely effective, the basins must be located downstream of the last sanitary connection to the combined trunk sewer and be provided with adequate pumping capacity for withdrawals to the transport system. Consolidation of the present 41 overflows to 15 subregional shoreline basins sites is fully endorsed. Details of the basin design and associated site problems are similar to upstream basins. These issues need further consideration.

Tunnel Storage — Tunnel storage as presented in the Master Plan is merely an extension of the upstream storage basin concept in that it is completely independent of the transport system. Maintaining good separation and incorporating the full control flexibility of upstream basins into tunnel storage elements has resulted in what appears an overly complex conceptual design. By simply increasing the tunnel size and constructing a single tube greater advantage can be gained from the spatial and temporal characteristics of rainfall. Thus, rather than having each storage element accessible only to its own tributary area, operation of the storage capacity can form a common storage facility available to any area tributary to the tunnel. As the lowest unit storage costs are associated with large diameter systems, a significant cost savings should be realized.

Waste Treatment

The split-flow modular treatment plant proposed in the Master Plan Report for wet and dry season operations offers the most efficient treatment concept available. The system can be increased in capacity to allow any given level of control for wet weather flows. The pilot plant studies will provide data necessary for final design of the primary and secondary treatment units. The storage capacity available in the primary treatment units can be effectively utilized thus reducing the need for shoreline retention basin storage and tunnel storage provided transport capacities are sufficiently large to be nonrestrictive.

Treatment plant design should permit maximum discharge from the individual units of the primary system prior to filling the available units and prior to utilizing storage available in other parts of the system. Maximum benefit can be achieved from the available storage capacity at the plant through individual modular parallel units designed for independent operation.

Secondary treatment by either chemical or biological processes is properly recognized in the Plan as the minimum acceptable level for treatment of dry weather discharge to the ocean. Primary treatment with possible chemical addition is the highest level that appears appropriate for wet weather discharges; however, regulations have not been established to define its acceptability.

Effluent Disposal

The Master Plan proposes discharge to the ocean of all dry weather and wet weather flows thus eliminating the problem of continually upgrading requirements for Bay discharge and the possibility that discharge to the Bay will eventually be prohibited. Demonstrable water quality problems result from Bay discharge. Assurance against environmental risk for discharge in the Southeast area would eventually require treatment superior to secondary.

The risk of environmental damage from ocean discharge of properly treated effluent is very slight. Recent detailed studies of the effects of the five largest municipal discharges to the ocean from California have shown that no adverse environmental impact is likely if pesticide concentrations are low and organic solids are efficiently removed.

Natural water quality conditions in the proposed disposal area fluctuate greatly. Winter and spring outflows from the Sacramento-San Joaquin Delta result in high concentrations of very turbid fresh waters carrying large silt loads out through the Gate and into the Gulf of the Farallones. Summer conditions in the discharge area are virtually unaffected by fresh waters from San Francisco Bay. Currents in the area are highly variable and are dependent upon local winds, oceanic season, Delta outflow, and instantaneous weather conditions. With these highly variable natural conditions, the effect of properly treated and dispersed effluent will be virtually nonexistent.

Compliance with regulations governing ocean disposal cannot be assured without completion of additional studies. There is also concern of possible effects of the waste discharge on the crab populations. The oceanographic work should be directed to answer these concerns. Studies should include detailed evaluation of the current patterns in the area to allow accurate calculation of available dilution capacities and the rate and direction of movement of the waste field. This work is essential to locate the best point of discharge and to provide data for design of the ocean outfall.

System Control

The centrally located control system relies on sensing devices to measure rainfall and flow in the collection system. The monitoring system has been developed to a reasonably high degree of reliability and accuracy. Signals are transmitted by telephone lines which could present some reliability problems. A system of parallel lines or alternate route systems would increase reliability; however, such duplicate facilities are not considered necessary at this time.

The information collected at the central receiving station is continuously fed into computers to record and display system status and form a basis for storm pattern prediction. The computer can print a visual image of the storm pattern at any time. After analysis of the data, the individual storage or transmission units will be instructed either manually or automatically to operate in a particular mode. Operating instructions can be modified as the storm progresses. For example, when rainfall is intense in one area of the City local retention basins can be filled; as the storm moves across the City, these reservoirs can be emptied or remain full depending upon the need to assign treatment or transmission capacity to other areas of the City.

Operational signals will be transmitted on leased telephone lines. The equipment instructed to operate from the central control system includes large numbers and varying sizes and types of valves and pumps. The reliability of remote-control operation for 30 upstream retention basins, 15 shoreline retention basins, the crosstown tunnel storage system, and portions of the treatment plants appears to be a complicated subject; however, in reality it is not greatly more complex than automatic operation of pump stations which is common practice. Central remote control of the system appears desirable; however, the actual benefits have not been evaluated against real data. Prior to construction, it would be desirable to investigate the real benefits compared to a system which responds and is controlled by the hydraulic conditions at the individual basins.

The proposed study of retention basin operation and centralized automatic controls should be designed to provide answers to the following questions which are necessary prior to system design:

- The feasibility with regard to loss of degree of control and increase in reliability of a less complex control system which responds directly to flow in the system and available storage capacity in the retention basins.
- The reliability of information circuits and the advantages and disadvantages of using radio signals, leased-line telephone circuitry, or a completely independent circuit.
- The reliability of circuitry and control system equipment for operation of valves and pumps from one central remote location.
- The accuracy of prediction of storm and runoff characteristics as a storm progresses in time.
- The system response time.
- The risks at each point in the system of control-system malfunction and the need for built-in safety features.
- The potential problems and liability that may result from system malfunctions in terms of flooding, unnecessary bypassing, or transportation system overloading.

To be effective it is essential that the complete control system be fully managed and operated by the Department responsible for wastewater management. Adequate staffing with personnel experienced in computer operation and systems control is essential. Dependence upon other departments and private firms with other responsibilities will greatly reduce reliability unless very carefully managed. Operational technical functions in the use of computers, transmission equipment, etc., are support functions essential to effective utilization of the system to achieve the most efficient water quality control during any storm period.

ALTERNATIVE STAGING PROGRAMS

Definitions of Alternatives

Regulatory restrictions and time schedules limit control options and establish certain early high priorities. The primary regulatory restriction is secondary treatment of dry weather flows by 1978. The next priority is the control of bypass in the north shore and ocean beach areas. All alternative programs developed in this evaluation are analyzed for compatability with these basic priorities.

The basic alternatives evaluated are combinations and variations of facilities drawn from two basic sources: The Master Plan Report, and the Environmental Impact Statement-Dry Weather Water Pollution Control Project.

Eight alternative staging programs were evaluated; six of which emphasized early attainment of secondary treatment to comply with State and Federal regulations. The present worth of each was calculated. The time required to accomplish specific goals was determined for each alternative assuming a fixed annual rate of capital expenditure.

Comparison of Alternatives

Based upon the cost-effectiveness analysis of alternatives the following conclusions are made:

- Staging as proposed in the Master Plan Report of Sept. 15, 1971 would result in long delays in attainment of secondary treatment and would require interim improvements to comply with State and Federal requirements.
- The secondary treatment requirement for dry weather flows can most quickly be met by conveying North Point area wastes to the Southeast plant site, construction of secondary treatment facilities at Southeast, and Bay discharge of the effluent.
- Secondary treatment at Southeast for north area and Southeast area flows will result in major delays in attaining ocean disposal of dry weather and wet weather flows.
- Secondary treatment at Southeast will expedite control of wet weather flows in the North shore area due to the ability to utilize the existing North Point plant as a wet weather treatment facility. Based upon present worth analysis, no economic benefit results from constructing the northern section of the cross town tunnel in place of dry weather plan Phase I facilities for transport of dry weather flows from North Point to Southeast.
- The Plan which most rapidly achieves wet weather goals and provides very significant improvement in dry weather environmental control is secondary treatment for Southeast flows only and improvement of the North Point outfall, followed by implementation of wet weather program. This staging program would achieve secondary treatment for Southeast flows at an early date, but North Point would remain primary for a longer time period during a portion of which the effluent would be discharged to the Bay. Although the 1977 deadline for secondary treatment could not be achieved by this staging program, it is considered the most cost-effective.

THE RECOMMENDED MASTER PLAN

Based on the comparison of alternatives, a specific staging program is recommended for the Master Plan.

Phase I

Sufficient information is currently available upon which to recommend facility sizings and control levels for first phase facilities. Selection of facilities sizings and control levels for following phases should be based on cost-effectiveness analyses for each project phase prior to design. Recommended Phase I facilities are shown on Figure 2. Phase I facilities are summarized as follows:

Element	Cost-Million Dollars
1. Pipeline from North Point to Southeast	24
2. Upgraded and expanded Southeast STP	92
3. Improved Southeast outfall	7
4. Upgraded Richmond-Sunset STP	13
5. North shore wet weather treatment, storage, and transport facilities	38
6. Transport system from Richmond-Sunset to Southeast area	25
7. Wet weather capacity ocean outfall	30
Total phase I facilities	229

Raw waste from the North Point service area will be pumped to the Southeast treatment plant. The Southeast plant will provide secondary treatment for dry weather flows from the North Point and Southeast areas. The effluent will be discharged to the Bay through an improved outfall. Wet weather waste control facilities will be constructed to control overflows in the North shore area. The North Point plant will be converted to a wet weather facility to treat wastewaters from the area during storm periods. The Richmond-Sunset wastewater treatment plant will be improved to provide an effluent quality acceptable for continual ocean disposal. Effluent from the Richmond-Sunset plant will be transmitted to the Lake Merced area for ocean disposal.

Completion of Phase I facilities will result in compliance with secondary treatment requirements for all dry weather flows, near elimination of overflows to important North area beaches (to an average of less than six overflows per year), and significant reduction of overflows to ocean beaches.

Operation of recommended Phase I facilities, in conjunction with improvements to other wastewater discharges to the Bay, will result in substantial improvement of the aquatic environment of the Bay, particularly in nearshore waters adjacent to San Francisco during the winter and spring months. Annual number of days in which bacteriological swimming standards are exceeded will be greatly reduced. At North shore beaches violations on less than 10 days per year are expected. Normally these days will occur during the least desirable periods for swimming and beach recreation. Also, the aesthetic quality of waters and beaches in the Marina, Aquatic Park, and Fisherman's Wharf areas should be substantially improved except during the worst storm conditions.

Completion of Master Plan

The following staging of facilities constructed after completion of Stage 1 is envisioned.

Stage	Facility Description	Capital Cost [$ Million]
1	Phase 1	229
2	Oceanside wet weather transport and shoreline storage facilities	38-69
3	Pipeline and tunnel Southeast to Southwest and upstream storage	66-112
	Ocean outfall extension	15
4	Southeast wet weather transport facilities	11-28
5	Oceanside upstream storage facilities	14-91
6	Southwest Treatment Plant	127
7	Pipeline and tunnel from North Point area and upstream storage	35-118
	Remainder of storage and transport facilities North Point and Southeast areas	63-193
	Total Master Plan	598-982

The range of costs of these facilities are completely dependent on levels of control selected for subsequent phases. The cost ranges presented are for levels of control being considered by the City. It is entirely possible that the final sizing of some facilities may result in costs outside these ranges. Cost-effectiveness analyses must be used to precisely define the staging following Phase 1 and to determine the sizing and therefore the cost and degree of control.

Upon completion of the plan shown on Figure 3 raw waste from North Point and Southeast areas will continue to receive secondary treatment at the Southeast treatment plant. The secondary treatment plant at Richmond-Sunset will be retained. These treated effluents will be transmitted through the tunnel and pipeline systems to the Lake Merced area where they will be discharged approximately four miles offshore. The North Point plant will be abandoned. During storm conditions, flows exceeding the capacity of the secondary treatment plants at Southeast and Richmond-Sunset will be transported to a 1,000 mgd capacity treatment plant near Lake Merced (the Southwest Treatment Plant). The effluent will be discharged two miles offshore.

Chapter I

EXISTING TREATMENT FACILITIES

Information on existing treatment facilities is necessary to determine their current and anticipated adequacy and the feasibility of utilizing present facilities as a portion of a more advanced treatment system.

DESCRIPTION OF TREATMENT FACILITIES

The City of San Francisco currently operates three wastewater treatment facilities. Locations of these plants and the boundaries of their service areas are shown on Figure I-1. The present average dry weather flow to these plants totals about 105 million gallons per day (mgd). Table I-1 presents data on the physical and hydraulic characteristics of the three plants.

The North Point water pollution control plant is the largest of the three plants treating an average dry weather flow of approximately 65 mgd from a tributary area of 8,500 acres, 7,590 of which are sewered. Treatment consists of conventional primary treatment processes plus chemical coagulation with ferric chloride. Individual processes include prechlorination, screening, grit removal, preaeration, primary sedimentation with chemical coagulation, and postchlorination. Solids removed during treatment are conveyed through a force main to the Southeast water pollution control plant for further processing.

The Southeast plant treats approximately 19 mgd average dry weather flow from a tributary area of about 11,240 acres, 8,100 of which are sewered. Of the sewered area 7,500 acres are in San Francisco; 600 are in San Mateo County. Treatment consists of conventional primary treatment processes plus chemical coagulation. Various combinations of coagulants are used depending on treatment needs. Capability is available for use of lime, ferric chloride and polymers. Individual processes include prechlorination, screening, grit removal, preaeration, primary sedimentation with chemical coagulation, and postchlorination. Solids removed in the process along with solids conveyed from the North Point plant are treated by gravity thickening, anaerobic digestion, elutriation, chemical conditioning, and vacuum filtration. Sludge cake is disposed of at a land fill.

The Richmond-Sunset water pollution control plant currently treats approximately 21 mgd average dry weather flow from tributary area of about 10,470 acres, of which about 9,000 acres are sewered. Treatment consists of conventional primary treatment plus chemical coagulation with ferric chloride. Individual processes include screening, grit removal, primary sedimentation with chemical coagulation, and chlorination. Solids removed during treatment are processed by two-stage anaerobic digestion, elutriation, chemical conditioning, and vacuum filtration. Most of the sludge cake is utilized as ground fill and soil stabilizer in Golden Gate Park.

The flow weighted mean quality of treated dry weather flow from the three treatment plants prior to and following installation of chemical addition facilities is given on Tables I-2 and I-3. The addition of chemicals to the primary treatment systems has resulted in a significant improvement in the quality of effluent from the City's treatment plants. The effluent quality is intermediate between that expected for primary and secondary treatments. It is not yet adequate to assure consistent compliance with waste discharge requirements.

OPERATION DURING STORM PERIODS.

The hydraulic capacities of the treatment plants shown on Table I-1 have been used extensively in analyzing existing control of wet weather flows. Visits to the treatment plants have revealed that the present equipment is unable to handle the rated flows. At the North Point plant the installed pump capacity totals only 190 mgd. Flow into the plant is throttled when the flow reaches 160 mgd and frequently at lesser rates. The bar screens are the last of the original screens and cannot handle the load of screenings received during wet weather. During the first major storms of the season, it is sometimes necessary to throttle the flow into the plant to as little as 50 mgd.

At the Richmond-Sunset plant, flooding occurs in the pre-treatment building at a flow of 50 mgd. The plant hydraulic capacity is rated at 70 mgd. Computations of the average flow to the three treatment plants during the 1969-70 rainfall year indicate that not over 1.5 billion gallons of storm flow was collected and treated. This was in a year of average rainfalls in which 2.8 billion gallons of storm flow should have been treated.

These apparent problems can be corrected by the installation of new or additional bar screens and pumps in which case it is believed that the interceptors could deliver the normal 2.8 billion gallons of storm flow to the treatment plants annually.

REMOVAL EFFICIENCIES

Table I-4 summarizes available information on the treatment facility removal efficiencies prior to and following the use of chemical addition facilities. At North Point and Southeast removal efficiencies of suspended solids are presently 74 percent and 78 percent respectively, which is very near that attainable by secondary processes. BOD removals, however, average only 47 percent and 56 percent respectively, which is significantly less than that required to meet the provisions of Federal law. Although additional interim improvements are being made, it is apparent that major capital expenditures to provide full secondary treatment by 1977 cannot be avoided.

Removal efficiencies presented in Plate IV-30 (Ref. 2) for BOD, suspended solids, and grease are not consistent with the data presented in Appendix Section 2, Tables 7, 8, 9, 10, and 12 (Ref. 30). Information presented on Plates IV-26 and IV-27 (Ref. 2) is also inconsistent with data in the appendix tables. The information presented on Table I-2 under Treatment Plant Monitoring and Table I-4 under Primary have been calculated from the appendix table data. The removal efficiency for wet weather months presented in Plate IV-30 (Ref. 2) are not representative of efficiency during storm runoff. Rainfall during these months occurs only about 10 percent of the time. The mean monthly removal values would therefore be greatly influenced by conditions when runoff did not occur. Only major changes in treatment efficiency would be evident from data presented in this manner.

The only insufficiency of data on existing conditions presented in the Master Plan is related to the time period for which removal data is presented. This period, June 1969 through December 1970, is prior to installation of chemical coagulation facilities at the treatment plants. As shown on Table I-4 removal efficiencies have significantly improved under this new operational mode and the effluent is now far superior to that which can be produced by plain sedimentation.

MASS EMISSIONS

The existing sewage collection and treatment system is capable of treating an estimated 38.6 percent of the storm waters and 98.3 percent of the sanitary wastes, thus allowing reduction of pollutant loading in the storm water as well as in the sanitary flows.

Table I-5 shows the extent to which emissions are controlled by the existing system. A shown significant percentage of suspended solids and floatables are bypassed. The quantities for other parameters are less than 7 percent of the total mass emissions in all cases. Table I-6 shows the effectiveness of the existing system at removal of pollutants.

The basic data can be used to calculate the effectiveness of alternative combinations of levels of treatment and bypassing of untreated waste. Table I-7 compares emissions with a separate sewer system and the existing system. The data shows that with the level of treatment now provided at San Francisco, the mass emissions for some parameters are significantly less than would be provided by a separated sewer system.

Bypassed sanitary waste accounts for an average of 1.7 percent of the total sanitary waste generated in the area. Although the sanitary waste is a relatively small fraction, the combined bypassed waste contains large concentration of floatables and coliform organisms contributed by this sanitary waste. Treatment of 39 percent of the storm waters prior to discharge results in a reduction of the mass emissions which would not be provided by separate sanitary and storm sewer systems.

DRY AND WET WEATHER OUTFALLS

Figure I-1 shows the location of the outfalls from the three wastewater treatment plants and the bypass outfalls used when stormwater flow exceeds the capacity of the treatment plants or the sewer system. The Mile Rock outfall carries both Richmond-Sunset treatment plant effluent and bypassed storm flows.

DATA ANALYSIS

The available data is adequate to permit consideration of alternative solutions that may incorporate existing facilities. No additional data are needed for purposes of master planning. Considering existing and anticipated water quality and effluent quality requirements, the data show the existing facilities to be inadequate. The Master Plan properly concluded that the existing treatment facilities are inadequate in that an effluent quality acceptable for discharge cannot be produced without very major improvements during both dry weather and storm conditions.

Consideration should be given to incorporating existing facilities into the staged program of improvement to maximize the control system efficiency during the implementation period. This is particularly applicable at North Point where it may be possible to use the plant for storage and treatment if it is abandoned as a dry weather facility.

TABLE I-1

EXISTING TREATMENT FACILITIES

	North Point	Richmond-Sunset	Southeast
Flow			
Mean (mgd)	65	21	19
Hydraulic Capacity (mgd)	190	70	70
Bar Screens			
Total Channel Width (ft.)	40	15	17
Bar Thickness (in.)	3/8	3/8	3/8
Clear Space (in.)	3/4	3/4	3/4
Grit Chambers			
Velocity — at mean flow (ft./sec.)	0.8(1)	0.2(2)	0.1(2)
Detention Time at mean flow (min.)	2.1(1)	4.9(2)	6.0(2)
Total Volume (1000ft^3)	25	9.5	10.5
Preaeration & Mixing Tanks — Total Vol. (1000ft^3)	181		112
Sedimentation Tanks — Detention Time at Mean Flow (hrs.)	0.5(2)		1.05(2)
Detention Time (hrs) at mean flow	1.5(2)	2.1(2)	2.8(2)
Overflow Rate (gal/ft^2/day) at mean flow	1280(2)	850(2)	760(2)
Total Volume (1000 ft^3)	580	225	290
Chlorination			
Chlorine Contact Time (min.) at mean time	2.7	50	
Solids Treatment	All solids except grit pumped to Southeast for treatment	(in outfield sewer)	
Thickening Tanks			
Total Volume (1000 ft^3)			26
Digesters			
Number		2	10(3)
Total Volume (1000 ft^3)		423	2400

(1) Two tanks operating
(2) All tanks operating
(3) Three used under normal operation
Ref. 18 Tables 2-1, 3 and 5

TABLE I-2

MEAN QUALITY OF PRIMARY TREATED SANITARY SEWAGE FROM THE CITY OF SAN FRANCISCO

		Data Source	
Parameter	Units	Brown & (1) Caldwell	Treatment Plant Monitoring(2)
PHYSICAL CHARACTERISTICS			
Floatables	mg/1	2.2	
Settleable Solids	ml/1	0.58	
Suspended Solids			
Total	mg/1	135	97
Volatile	mg/1	113	
Turbidity	JTU	57	
CHEMICAL CHARACTERISTICS			
BOD (5-day)	mg/1	160	163
COD	mg/1	380	
Grease & Oil (HEM)	mg/1	43	39
Nitrate as N	mg/1	2.16	
Nitrite as N	mg/1	0.10	
Nitrogen (Ammonia)	mg/1	18	
Nitrogen (Organic)	mg/1	18	
Nitrogen (Total Kjeldahl)	mg/1	36	
Phenols	mg/1	0.09	
Phosphate (Ortho)	mg/1	22	
Phosphorous (Total)	mg/1	29	
Metals			
Aluminum	mg/1	11	
Arsenic	mg/1	0.009	
Cadmium	mg/1	0.03	
Chromium (total)	mg/1	0.27	
Copper	mg/1	0.205	
Iron (total)	mg/1	2.20	
Lead	mg/1	0.17	
Mercury	mg/1	0.025	
Nickel	mg/1	0.06	
Silver	mg/1	0.007	
Zinc	mg/1	0.35	
TICH	ug		
MBAS	mg/1		
BIOLOGICAL CHARACTERISTICS			
Coliform Organisms	MPN/100mls		
Fecal Coliform	MPN/100mls		
Toxicity (3)			
TL^{96}_{50}	%	60	
96 hour % survival	%	14	

(1) Reference 18-Tables 3-4, 5, 13, 14, 15, 23, 24, 25, and Ref. 2 Plates IV-17 through 23 — Based on one week of intense sampling

(2) Ref. 30, Section 2, Tables IV-10, 11, 12 — Based on monitoring data for July 1969 through December 1970

(3) After chlorination — Stickleback test fish

TABLE I-3

MEAN QUALITY OF PRIMARY WITH CHEMICAL ADDITION TREATED SANITARY SEWAGE FROM THE CITY OF SAN FRANCISCO

Parameter	Units	North Point (1)	Richmond -Sunset (2)	Southeast (3)
PHYSICAL CHARACTERISTICS				
Floatables	mg/1			
Settleable Solids	ml/1	0.01	0.25	0.13
Suspended Solids				
Total	mg/1	46	72	50
Volatile	mg/1			
Turbidity	JTU			
CHEMICAL CHARACTERISTICS				
BOD (5-day)	mg/1	102	138	82
COD	mg/1	171		272
Grease & Oil	mg/1	22	39	19
Nitrate	mg/1	1.22		0.25
Nitrite	mg/1	0.05		0.03
Nitrogen (Ammonia)	mg/1	6.8		12.1
Nitrogen (Organic)	mg/1			
Nitrogen (T. Kjeldahl)	mg/1	14.4		14.7
Phenols	mg/1			
Phosphate (Ortho)	mg/1	6.7		
Phosphorous (Total)	mg/1	12.2		10.9
Metals				
Aluminum	mg/1			
Arsenic	mg/1			
Cadmium	mg/1			
Chromium (Total)	mg/1	0.018		0.185
Copper	mg/1	0.084		0.08
Iron (Total)	mg/1			
Lead	mg/1	0.115		0.075
Mercury	mg/1			
Nickel	mg/1			
Silver	mg/1			
Zinc	mg/1	0.345		0.325
TICH	ug			
MBAS	mg/1			
BIOLOGICAL CHARACTERISTICS				
Toxicity				
TL^{96}_{50}	%			
96 hr.% survival	%			

(1) North Point WPCP Monitoring Reports for 11/72 and 12/72
(2) Richmond-Sunset WPCP Monitoring Reports for 10/72 and 11/72
(3) Southeast WPCP Monitoring Reports for 11/72 and 12/72

TABLE I-4

TREATMENT EFFICIENCIES [% REDUCTION]

	North Point			Richmond-Sunset			Southeast		
	B&C[1]	City[2]	City[3]	B&C	City	City[4]	B&C	City	City[3]
Treatment Process:	Primary		Chemical Primary	Primary		Chemical Primary	Primary		Chemical Primary
Parameter									
PHYSICAL CHARACTERISTICS									
Floatables	22			25			33		
Settleable Solids									
Suspended Solids									
Total	53	59	74	61	65	51	32	39	78
Volatile	50			61			37		
Turbidity									
CHEMICAL CHARACTERISTICS									
BOD (5day)	22	34	47	37	28	32	29	30	56
COD	33			33			23		
Grease & Oil	34	47		23	20		31	44	
Nitrate									
Nitrite									
Nitrogen (Ammonia)									
Nitrogen (Organic)									
Nitrogen (Total Kjeldahl)	12			6			-13		
Phenols	0			-12			-5		
Phosphate (Ortho)									
Phosphorous (Total)	14			-5			8		
Metals									
Aluminum				39				-3	
Arsenic									
Cadmium				-50					
Chromium (Total)	-138			50			59		
Copper	-12			39			-9		
Iron (Total)	24			45			-70		
Lead	-12			-180			-6		
Mercury									
Nickel	-441			50			0		
Silver	-13			50			0		
Zinc	18			> 67			-3		
TICH	2			16					
MBAS									
BIOLOGICAL CHARACTERISTICS									
Toxicity									
TL_{50}^{96} [5]	1			-51			-17		
96 hr. % survival[5]	38						< -100		

(Footnotes on following page)

TABLE I-4 [cont'd]

[1] Reference 18, Tables 3-4, 5, 13, 14, 15, 23, 24, 25, and Ref. 2 Plates IV-17 though 23 — Based on one week of intense sampling.
[2] Ref. 30 Section 2, Tables IV-10, 11, 12 — Based on monitoring data for 7/69-12/70
[3] Southeast and North Point WPCP Monitoring Reports for 11/72 and 12/72
[4] Richmond-Sunset WPCP Monitoring Reports for 10/72 and 11/72
[5] After chlorination — Stickleback test fish

TABLE I-5

EXISTING WASTEWATER CONTROL (1)

Parameter	To Treatment Plants (M lb/yr)[2]	Percent of Total	Bypassed (M lb/yr)	Percent of Total	Total Raw loading (M lb/yr)
PHYSICAL CHARACTERISTICS					
Floatables	0.90	71	0.37	29	1.27
Settleable Solids					
Suspended Solids					
Total	65.2	82	14.5	18	79.7
Volatile					
Turbidity					
CHEMICAL CHARACTERISTICS					
BOD (5-day)	71.1	97	2.5	3	73.5
COD	140.5	95	8.1	5	148.6
Grease & Oil	20.4	94	1.3	6	21.7
Nitrate					
Nitrite					
Nitrogen (Ammonia)					
Nitrogen (Organic)					
Nitrogen (Total Kjeldahl)	9.7	94	0.6	6	10.3
Phenols					
Phosphate (Ortho)	7.1	99	0.08	1	7.2
Phosphorous (Total)					
Metals					
Aluminum					
Arsenic					
Cadmium					
Chromium (Total)					
Copper					
Iron (Total)					
Lead					
Mercury					
Nickel					
Silver					
Zinc					
TICH					
MBAS					

(1) Base data from: (a) Ref. 2, Plates IV-17 through IV-23.
(b) Ref. 30, Section 2
(c) Ref. 3 and 11

(2) Million Pounds per Year

TABLE I-6
EFFICIENCY OF EXISTING SYSTEM [1]

Parameter	Total Raw Loading (M lb/yr)	Removed By Treatment (M lb/yr)	Discharged In Treated Effluent (M lb/yr)	Bypassed (M lb/yr)	Total Disch. To Rec'g Waters	Percent Removal By System (%)
PHYSICAL CHARACTERISTICS						
Floatables	1.27	0.23(2)	0.67	0.37	1.04	18(2)
Settleable Solids						
Suspended Solids						
Total	79.7	45.7	19.5	14.5	34.0	57
Volatile						
Turbidity						
CHEMICAL CHARACTERISTICS						
BOD (5-day)	73.5	35.5	35.5	2.5	38.0	48
COD	148.6	89.9	50.6	8.1	58.7	60
Grease & Oil	21.7	12.6	7.8	1.3	9.1	58
Nitrate-N						
Nitrite-N						
Nitrogen (Ammonia)						
Nitrogen (Organic)						
Nitrogen (total kjeldahl)	10.3	6.0	3.7	0.6	4.3	58
Phenols						
Phosphate (Ortho)	7.2	4.8	2.3	0.08	2.4	67
Phosphorous (Total)						
Metals						
Aluminum						
Arsenic						
Cadmium						
Chromium (Total)						
Copper						
Iron (Total)						
Lead						
Mercury						
Nickel						
Silver						
Zinc						
TICH						
MBAS						

(1) With chemical addition primary treatment

(2) With conventional primary treatment

TABLE I-7

MASS EMISSIONS FOR PRESENT SYSTEM VS. SEPARATING THE SEWERS [1]

	Sewage Treatment Plant Effluent (M lb/yr)	Bypass Loading (M lb/yr)	Total Discharge Present Condition (M lb/yr)	Storm[2] Cont. Load. (M lb/yr)	Loading with Separate System (M lb/yr)	Results of Separation % Increase+ or Decrease-
PHYSICAL						
Floatables	0.67	0.37	1.04	0.27	0.94	-10%
Set. Solids						
Sus. Solids	19.5	14.5	34.0	32.5	52.0	+53%
Turbidity						
CHEMICAL						
Grease & Oil	7.8	1.3	9.1	1.31	9.1	Zero
BOD	35.5	2.5	38.0	----	----	----
COD	50.6	8.1	58.7	13.5	69.1	+9%
Total Nitrogen	3.7	0.6	4.3	0.67	4.4	Zero
Ortho Phosphate	2.3	0.1	2.4	0.11	2.4	Zero
Metals						
Aluminum						
Arsenic						
Cadmium						
Chromium						
Copper						
Iron						
Lead						
Mercury						
Nickel						
Silver						
Zinc						
TICH						
BIOLOGICAL						
Coliform						
Fecal Coliform						
Toxicity						

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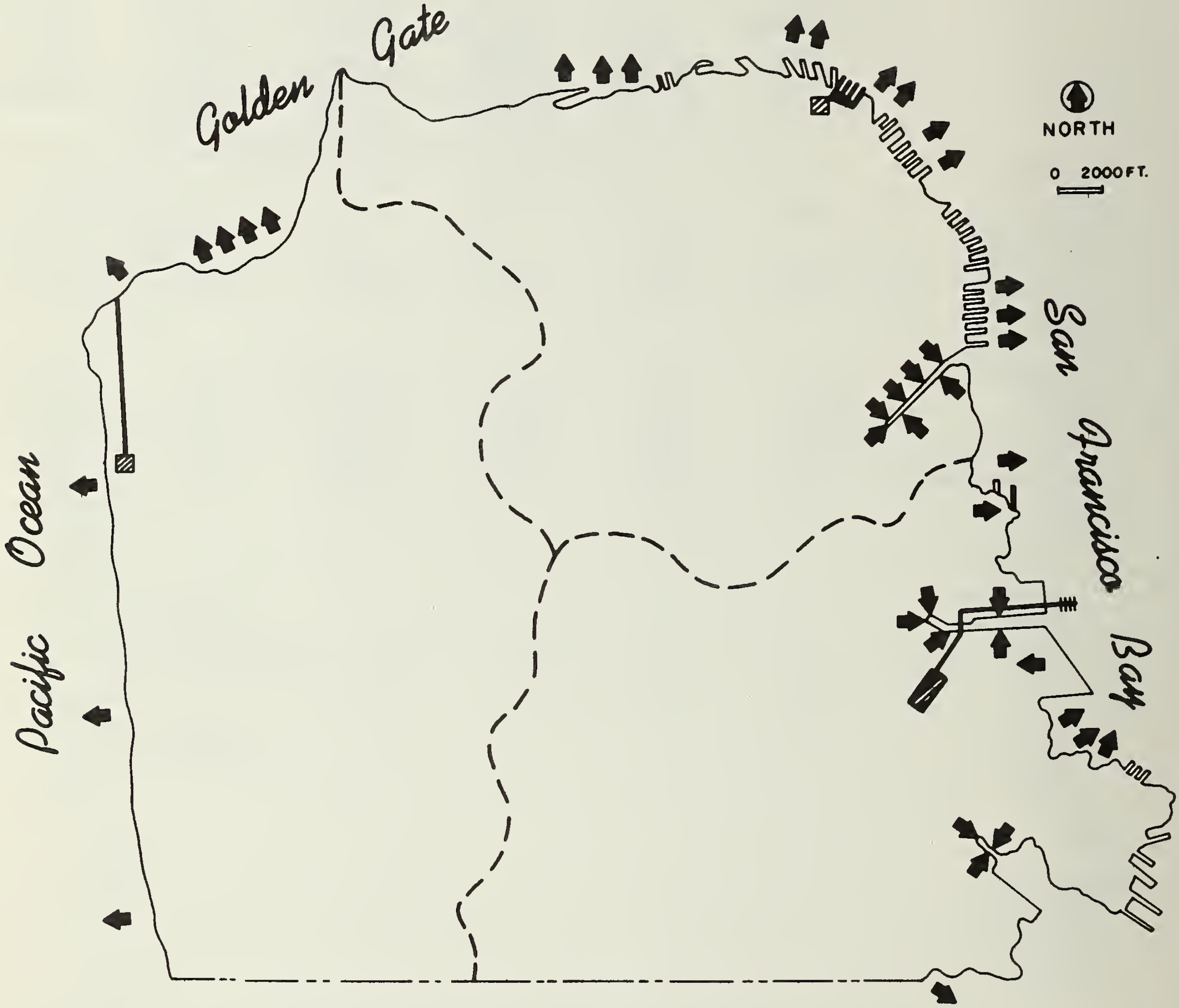
1 With Chemical Addition Primary Treatment.

2 From Plate IV-32 Reference 2.

Figure I-1

EXISTING FACILITIES



▨ Treatment Plant

——— Outfall

- - - - Drainage Basin Boundary

➡ Bypass Location

Chapter II

WASTEWATER QUANTITY

The quantity of rainfall runoff from the land mass of San Francisco and the quantities of dry weather flow to the City's treatment plants as developed and used in the Master Plan Report are discussed in this chapter.

Estimates of flow quantity origins, both in time and space, and magnitudes are of primary importance in Master Plan development. To a large extent, they determine the sizes, arrangements, and locations of environmental improvement facilities; hence their costs.

During rains, the volume of flow in affected combined sewers increases enormously and large quantities of mixed sanitary sewage and stormwater overflow to the receiving waters without treatment. When localized rainfall causes high storm flow in a portion of the interceptor, raw sewage can erupt from succeeding portions of the interceptor, including portions through areas not subject to the rain, as the waste is transmitted through the system. When rains are light, the overflow may consist of 50 percent sanitary waste but the total overflow quantity is small. During very heavy rains, the overflow may consist of as little as 2 percent sanitary waste but the quantity discharged may be very great and contain 96 percent of the domestic sewage flow at peak discharge.

The dry weather sanitary flow from all of San Francisco is roughly equivalent to the runoff from a rainfall intensity of 0.01 inches per hour over the same area. Approximately 95 percent of the historical rainfall from U. S. Weather Bureau, Federal Office Building, records exceeds this amount, often by 50 to 100 times or more, resulting in total dominance from storm flows in the system in times of wet weather.

TOPOGRAPHY AND LAND USE

San Francisco is located on a collection of hills, comprising part of the coastal range, and is surrounded on three sides by salt water. The streets slope steeply toward the water on the west and north and toward a flat coastal strip along the east side of the business district. A relief map of San Francisco is shown on Figure II-1. Table II-1 summarizes the more significant topographical factors.

The natural drainage is to the Bay for North Point and Southeast districts, and to the ocean for the Richmond-Sunset district. The City reaches a maximum elevation of 922 feet above sea level at the confluence of the three major districts.

The sewered area, 24,014 acres, is 84.4 percent of the gross area of 28,508 acres. Except for parks, military reservations, and mountain slopes the City is practically 100 percent developed. The west side is predominantly residential, mostly single-family houses. The North Point plant includes the downtown commercial area with its large daytime work force from all over the Bay area, a large industrial area, and a large residential area, predominantly multi-family units. The area tributary to the Southeast plant, while mostly single family residential, includes a large industrial area of industries producing liquid wastes which greatly influence the characteristics of the sewage received at that plant. The land uses of the various areas of the City have been established and only minor changes are to be expected in the near future.

The shoreline has also been fully developed. The east side of the City from Hunter's Point to Fisherman's Wharf consists of docks and shipping terminals. The North side of the City includes a swimming beach at Aquatic Park and recreational facilities at the Marina. Bakers Beach and Phelan Beach lie outside the Golden Gate, and Ocean Beach extends along the entire length of the western shore from the Cliff House to Fort Funston.

Table II-2 summarizes representative land use data.

Two population projections are available. From information used in the Bay-Delta Study the projected changes in land use and population by 1990 are relatively small and generally limited to the North Point district, the population is expected to increase from 740,115 to 833,090 (12.5 percent) with 87 percent of the increase in the North Point district. City planning projections forecast a slower population growth rate reaching 755,572 in 1990 and 780,000 in 2020. Residential land use is expected to decrease by 31 percent as more land is converted to commercial and public use.

EXISTING DRAINAGE SYSTEM

The City's existing drainage system is shown on Figures II-2 (schematic), II-3 (adequate and inadequate major transport sewers), II-4 (interceptors, pumping stations, and treatment plants), and II-5 (locations of discharge overflows). Approximately 50 percent of the major transport sewers are reported to be inadequate for the computed (rational method) 5-year storm flow. A third of the inadequate sewers are reported as capable of carrying less than one-half the computed design flow. Excluding the pumping which occurs at each treatment plant, 6,451 acres of the sewered area (27 percent) are served by pumping and the remainder by gravity.

The discharge locations of storm overflows and computed 5-year storm flows are summarized in Table II-3. For such a storm approximately 37 percent of the discharge of storm flows is to the North Point area, 31 percent to the east shore, and 32 percent to the west shore. Approximately 68 percent of the bypassed waste is discharged inside the Golden Gate Bridge. For planning purposes and for evaluation of effects on receiving waters, the Master Plan has grouped the outfalls into the 15 major points of discharge, 5 from each district.

U. S. WEATHER BUREAU HISTORICAL RAINFALL DATA

Sixty-two years of rainfall recorded at the Federal Office Building gage, located in the northeast quadrant of the City, and twenty-one concurrent years at the Richmond-Sunset gage, northwest quadrant, were analyzed for rainfall intensities, frequencies, and volume. These data have been used for a computer study to correlate the volume of storage basins with the proposed rate of stormwater treatment and the frequency of overflows. The data is also the basis of the rainfall intensity-duration-frequency curves shown on Figure II-6.

Comparisons of significant values from both data sets are presented in Table II-4. The average annual precipitation and monthly variations from the Federal Building gage are summarized in Table I-5. Table II-6 shows the average hourly intensities representing 62 years of record at the Federal Building Gage.

SPATIAL AND TEMPORAL VARIANCE OF RAINFALL PATTERNS

With its extreme variation in topography and high exposure to ocean storms, considerable variation exists in rainfall intensities across the City at any time during a storm. Recognizing this concept, the City has engaged in continuous monitoring of the rainfall at 19 or more rain gages throughout the City, beginning with the 1969-70 rainy season. For that season, the data indicated a 15 percent lower overall average volume of rainfall over the whole City than indicated by the Federal Building gage. Data collected on one large storm during the 1970-71 season and during the large storm in October 1972, indicate that large storms move across the City, frequently from northwest to southeast, with the area of most intensive rainfall covering only a small part of the City at any one instant and changing from minute to minute as the storm progresses. Both the maximum intensity of rain and the total rainfall vary widely throughout the City.

In addition, the City has compared rainfall data from the Richmond-Sunset gage and Federal Building gage. Table II-4 shows a comparison of rainfall and overflows for existing conditions based on both records. The average rainfall per storm event, its duration, and the amount of overflow per storm are approximately the same, but the number of overflows is 72 per year based on the Richmond-Sunset gage compared to 82 based on the Federal Building record.

This discrepancy could be due to the different periods covered by the two records. A study was made of the overflows that would have resulted based on the two gages for the years 1953-1968 if the Master Plan had been in operation for those years with a storage capacity of 0.25 inches and a treatment rate equivalent to the runoff from 0.10 inches per hour of rainfall. The results presented in Table II-7 show 4.75 overflows per year based on the Richmond-Sunset records compared to 4.0 based on the Federal Building gage for the same years, and the average overflow volume using Richmond-Sunset records would be 13 percent greater.

Table II-7 compares the results based on the entire record at the two gages. These two tables indicate that the 62-year Federal Building record covers a period of more frequent but less intense rainfall than the shorter Richmond-Sunset record.

Table II-8 shows the results of a study of the Federal Building and Richmond-Sunset records. The analysis used Alternate B storage facilities and a 0.1 in/hr. storage withdrawal rate. The rain gages were considered representative of rainfall on their respective sides of the City and the records analyzed for overflows. As shown in Table II-8 a majority of the overflow events would have occurred only in the vicinity of one of the rain gages.

Twenty-two out of the 37 simultaneous overflow events would have differed in total amount overflowed by 0.10 inches or more. Sixteen of these would have had greater overflow on the west side of the City compared to six on the east side.

The above analysis confirms the results to date obtained from the rainfall monitoring program that rainfall intensity and quantity are highly variable over the City. This variation is so great that approximately 64 percent of overflow events occur only on one side of the City.

This information is in general agreement with the data on distribution of intense rainfall contained in American Sewerage Practice, Vol. I, 2nd Edition, p. 277, which gives the ratios of average intensity to maximum intensity for areas of 5,000 acres based on storms in Boston and New Orleans. These data are shown on Table II-9.

The rainfall monitoring program results for the 27 events recorded between November 1971 and April 1972 show that nine storms entered the City from the northwest, eight from the west, six from the southwest, two from the south, one from the north, and one from the southeast. The rainfall release computed for the entire City varied from 3.69 million cubic feet in 8 hours, 24 minutes, to 129 million cubic feet in 46 hours, 46 minutes. Of the total 800 million cubic feet released, 40 percent occurred in Richmond-Sunset drainage basin, 27 percent in North Point district, and 32 percent in the Southeast sector of the City.

The available data on runoff frequency, intensity, and distribution are sufficient to define the quantitative aspects of the problem of intercepting and collecting stormwater runoff for development of the Master Plan concept. Further data is needed and is being collected for final design of facilities.

Runoff coefficients for individual areas based on assumed pipe friction factors will be determined by the monitoring program. While it would be desirable to check the friction factors as well, this would be difficult since the two coefficients are interdependent, the proposed procedure will yield satisfactory data.

RUNOFF QUANTITIES

The average annual quantities of storm and sanitary flows treated and bypassed under existing conditions are shown in Table I-10. Of the total combined waste flow of 45.3 billion gallons per year, 8.8 billion gallons is stormwater and 36.5 sanitary sewage. Approximately 87 percent of the combined flow is treated and 13 percent is bypassed.

Under existing conditions, it is assumed that runoff from the first 0.02 inches of rainfall in any hour will be intercepted for treatment at the existing plants. Any hourly rainfall intensities in excess of this amount will result in overflows to the Bay or ocean through a system of 41 overflow structures. The average annual frequency of overflows is summarized in Table II-11 using an average runoff coefficient of 65 percent. The data show an average of 82 overflow events per year and that overflows occur 2.35 percent of the time.

Overflows occur on the average 206 hours per year at an average rate of 700 mgd. When overflows occur, the interceptors are full transporting up to 300 mgd to the three existing treatment plants. Dry weather flow amounts to about 105 mgd on the average. The North Point drainage basin contributes about 27 percent of the rainfall and 62 percent of the sanitary sewage. The Richmond-Sunset basin contributes approximately 40 percent of the rainfall and 20 percent of the sanitary flow. The Southeast drainage basin handles about 33 percent of rainfall and 18 percent of the sanitary sewage. From this information, the mean composition of wastewater bypassed from the entire City is estimated at 10 percent sanitary sewage and 90 percent stormwater. The mean content of sanitary sewage in waters bypassed from the North Point, Richmond-Sunset, and Southeast basins are estimated at 22 percent, 6 percent, and 6 percent, respectively.

The distribution of overflows of specified return frequency is summarized in Table II-12 for existing conditions.

Estimated peak discharge wet weather flows at each of the 41 outlets are shown on Table II-13. Values are given for storms that may be equalled or exceeded once in 5,10, 25, 50, and 100 years. These flows have been computed by the rational method using rainfall intensity-duration-frequency curves. This method is in widespread use throughout the United States in spite of its well known deficiencies. It assumes uniform rainfall over the drainage area. Correct results are dependent on satisfactory estimates of inlet time and time of concentration as well as the runoff coefficient. Typical inlet times vary from 5 minutes to 30 minutes. Actual inlet time depends on the intensity of rainfall and the amount of rain prior to the period of intense rainfall, the slope of ground and street surfaces, the spacing of inlets, and the method of connecting roofs and other impervious areas to the sewers. The shorter the inlet time the greater the estimated peak flow.

San Francisco uses an inlet time of 5 minutes which would appear to be justified based on the above considerations. The time of concentration is usually computed by adding to the inlet time, the time of flow from the most remote inlet to the beginning of the stretch under investigation. This assumes the sewers are flowing full with the slope of the hydraulic grade line parallel to the invert. This can lead to considerable error in computing the capacity of old sewers which were installed with matching inverts, a common practice in the past, now universally and rightly condemned.

No attempt is made to determine the actual velocity or to allow for the storage capacity in the sewers. The latter can have a significant effect in reducing the peak flow. It is usually neglected since storm sewers are customarily designed for the 5 to 15 year storm and its neglect provides a factor of safety which will be of help in handling a larger storm.

The rational method gives an estimate of the peak flow only for each length of sewer. These peaks do not occur simultaneously and the flow passes down the sewer as a flood wave. For the design of sewers and retention basins, a method which determines the complete storm flow hydrograph is desirable. Several such methods have been developed for specific geographical areas including Los Angeles and Chicago. A computer program has been presented as part of the Storm Water Management Model prepared for the Environmental Protection Agency (Ref. 31). This program determines the flood hydrograph at any point in the sewer for any rainfall hyetograph. This model was tested on the Selby Street and Baker Street drainage areas in San Francisco. Table II-14 compares results of determining peak runoff with the rational method, the computer model, and direct measurement. The directly measured flows are contained in Reference 3.

The data in Table II-14 for Selby Street and Baker Street show the wide range of results obtained by the rational method and give some indication of its reliability compared with measured data and more sophisticated methods of computation. Additional data on runoff quantities should not affect the general arrangement of the Master Plan components or the consideration of the alternates. Additional data on rainfall and runoff now in the process of accumulation will effect the number, size, and location of upstream retention basins, the volume of tunnel storage provided, the capacity of the wet weather treatment facility, and the capacity of the transport system. The current monitoring program should provide sufficient data so that facilities serving several drainage areas such as tunnel storage, transport conduits, and the treatment plant can be most effectively sized with resultant economy to allow for variations in the spatial and temporal variations in the rainfall patterns.

DRY WEATHER FLOW PROJECTION

Future dry weather flows generated in areas now tributary to the existing treatment plants have been projected to the year 2020. Average and peak dry weather flows are shown in Table II-15 as are the present average flow and the estimated hydraulic capacities of the treatment plants. The hydraulic capacities of the plants listed in the table are used throughout the comprehensive report. As stated in the previous chapter these capacities are not presently being provided at the treatment plants but could be made available by the installation of new pumps and changes in the pre-treatment facilities.

For comparison, Table II-16 shows the Master Plan wet weather flows, including sanitary flow, planned for treatment. The treatment rate is based on a peak combined flow rate of 0.065 inches per hour at runoff from 24,014 acres which is equivalent to runoff from 0.10 inches per hour rainfall.

The estimated future total dry weather flow was taken at 93 percent of the Water Department projections estimated to the year 2020.

A discrepancy exists between the population figures presented in Table II-17 and that used in Ref. 30 Section 9 to project dry weather flows. Table II-17 summarizes a detailed study of land use distribution, population, and employment contained in Ref. 30, Section 8. This information shows an increase in population from 740,115 in 1965 to 833,000 in 1990 and an increase in employment from 556,664 in 1965 to 822,903 in 1990. Assuming that these latter figures are correct, future dry weather flow figures should be increased by about 10 percent for design purposes. The estimated year 2020 figure in the Bay-Delta Report is 200 mgd for San Francisco or 60 percent over the 125 mgd in Table II-14. There appears to be no justification for the high population estimates of the Bay-Delta Study.

TABLE II-1
TOPOGRAPHY

Plant (Drainage District)	Total Sewered Area Acres	Sewered Area above el. 50 %	Runoff Coef. %	Runoff Volume* % of Total
North Point	7,516		76.2	37
Richmond-Sunset	9,004		55.5	32
Southeast	7,494		62.9	31
Total or Average	24,014	54.1	65.0	100

*For equal rainfall distribution

TABLE II-2
LAND USE CHARACTERISTICS

Plant (Drainage District)	Industries & Mfg.*	Commercial Transp. & Utilities*	Residential*	Public Other*	Population 1965
North Point	15.3	15.4	39.1	30.2	353,836
Richmond-Sunset	1.7	3.9	55.8	38.5	220,028
Southeast	12.7	3.8	43.2	40.3	166,251
Total City	9.6	7.6	46.5	36.3	740,115

*Expressed as percent of total area

TABLE II-3

DISCHARGE LOCATIONS AND FLOWS

Plant (Drainage District)	No. of Outfalls	Computed 5-year Storm Flows, cfs Range	Total Flow From District
North Point	20	10-5,904*	8,879
Richmond-Sunset	8	8-1,824	6,461
Southeast	15	12-2,408	6,020
Total	43		21,360 = 13,780 MGD

*Part of interconnected network

TABLE II-4

HISTORICAL RAINFALL DATA AND COMPUTED OVERFLOW EVENTS UNDER EXISTING CONDITIONS*

	Federal Bldg.	Richmond-Sunset
Length of record, yrs.	62	21
No. of overflow events	5,071	1,511
Overflows per year	82	72
Avg. rainfall per event, in.	0.22	0.217
Avg. duration of rain, hours	2.5	2.4
Avg. duration of overflow, hrs.	2.5	2.4
Avg. overflow, in.	0.17	0.168
Hrs. of increased flow to treatment plants, avg.	4.7	4.2
Annual overflow, in.	13.884	12.096

*0 storage, 0.02 in/hr maximum flow through treatment plant

TABLE II-5

ANNUAL AND MONTHLY RAINFALL VARIATION. FEDERAL BUILDING GAGE

	Annual, 62 years of record
Average annual rainfall, in.	20.33
Maximum annual rainfall, in.	
Minimum annual rainfall, in.	
Average No. of rainy days/yr.	46

		Monthly, 40 years of record	
		Amount Inches	% of Annual
Wet weather avg.	(October-April)	20.67	94.9
	(December-February)	12.78	58.7
Wettest month avg.	(January)	4.89	22.4
Wettest month of record		11.47	
Dry weather avg.	(May-September)	1.11	5.1
	(June-August)	0.20	0.9

TABLE II-6

FREQUENCY DISTRIBUTION OF HOURLY RAINFALL INTENSITIES

Intensity, inches/hour	Percent of Time Equalled or Exceeded
0.01	94
0.05	72
0.10	47
0.20	20
0.55	1

TABLE II-7

OVERFLOWS UNDER PROPOSED MASTER PLAN, ALTERNATE B* BASED ON FEDERAL BUILDING AND RICHMOND-SUNSET RAINGAGES**

	Federal Building	Richmond-Sunset	Federal Building	Richmond-Sunset
Years of record	62	21	1953-1968	1953-1968
No. of overflow events	335	99	64	76
Overflows per year, average	5.4	4.7	4.0	4.75
Avg. rainfall per overflow event, in.	1.013	1.046		
Avg. duration of rain, hours	6.9	6.9		
Avg. duration of overflow, hours	2.3	2.6	2.5	2.9
Avg. overflow, inches ***	0.207	0.235	0.22	0.25
Hours of increased flow to treatment plants (overflow events only)	18.5	17.4		
Annual overflow, inches ***	1.121	1.106	0.88	1.19
No. of storm events per year with rainfall rates exceeding 0.10 in/hr	26.9	21.6		
Avg. rainfall per storm event, in.	0.442	0.478		

*0.25 in. storage, 0.10 in/hr rainfall treatment rate

**Data from Appendix Section 11, Plates 51 and 85, and Report Plates V-6A to F

***Inches of equivalent rainfall. To obtain overflow quantity, multiply by 0.65

TABLE II-8

COMPARISON OF OVERFLOW EVENTS USING TWO RAINFALL RECORDS[1] YEARS OF RECORD 1953-1968

Overflow Location	West side only	East side only	Both sides
Overflow Events	39	27	37
%	38	26	36

(1) Alternate B storage, 0.1 in/hr. withdrawal rate
Ref. 2 — Plates V-6A through 6F

TABLE II-9
DISTRIBUTION OF RAINFALL

Duration of Intense Rainfall	Ratio Average Intensity to Maximum — Percent
15 minutes	69
30 minutes	77
45 minutes	83
60 minutes	86

TABLE II-10
AVERAGE ANNUAL MASS VOLUMES OF SANITARY AND STORM FLOW

	Total	Treated (2)		Bypassed (2) (3)	
	BGY (1)	BGY	%	BGY	%
Sanitary waste	36.5	35.9	98.3	0.6	1.7
Storm waste	8.8	3.4	38.6	5.4	61.4
Total combined waste	45.3	39.3	86.8	6.0	13.2

(1) BGY — billion gallons per year

(2) For 206 hours/year of overflow and maximum treatment rate of 0.02 inches/hour

(3) Assumes that annual average sanitary waste content of bypassed flow is 10%

TABLE II-11
FREQUENCY OF OVERFLOWS

Average annual number of overflows	- 82 events
Average annual hours of overflows	- 206 hours
Average days per year overflow occurs	- 46 days
Percent of total time overflow occurs	- 2.35%
Percent of storm time overflow occurs	- 90%

TABLE II-12

DISTRIBUTION OF OVERFLOWS [1]

Item	Overflow Volume, million gallons North Point	 Richmond-Sunset	 Southeast	 Total
Average total annual	2400	2080	2010	6490
Frequency of occurrence:				
once in 5 years	300	254	246	800
once in 2 years	232	195	187	614
once per year	187	157	157	501
twice per year	157	120	120	397
four times per year	112	90	90	292

(1) Assuming uniform rainfall & using FOB gage.

TABLE II-13 ON FOLLOWING PAGE

TABLE II-14

COMPARISON OF RATIONAL AND HYDROGRAPH METHODS FOR DETERMINING PEAK FLOWS

Storm	Intense Rainfall in/hr	Rational Method cfs	Model cfs	Measured cfs
		Selby St. Area		
November 6, 1966	0.63	1350	780	740
		Baker St. Area		
April 4-5, 1969	0.12	17.4	15	25
October 14-15, 1969	0.27	39	32	13
October 14-15, 1969	0.46	67	56	—
December 19-20, 1969	0.72	105	82	—

TABLE II-13

OUTFALL NAMES, SIZES, FLOWS AND AREAS

OUTFALL NO	NAME	CONDUIT		TRIBUTARY ACRES		APPROX Tc		"C"	CA (TOTAL)	STORM FLOWS (cfs)										REMARKS
		SIZE	X-SEC AREA (sf)	TOTAL	SEWERED	MIN	SEC			5 YR.		10 YR.		25 YR.		50 YR.		100 YR.		
										I	Q	I	Q	I	Q	I	Q	I	Q	
11	Lake Merced	10'x11'-3"	95.0	2,169	1,541	30	24	.39	848	1.12	950	1.32	1,119	1.55	1,314	1.72	1,459	1.92	1,628	
12	Vicente	2 @ 5'dia.	39.2	1,731	1,577	24	44	.55	946	1.26	1,192	1.50	1,419	1.75	1,656	1.99	1,883	2.20	2,081	
13	Lincoln Way	3 @ 6'-6"	106.5	2,853	2,853	24	27	.50	1,425	1.28	1,824	1.51	2,138	1.78	2.537	2.01	2,864	2.22	3,164	
14	Mile Rock	9'x11'	80.7	1,154	1,043	24	46	.54	626	1.27	795	1.50	939	1.75	1,095	1.99	1,245	2.20	1,377	
15	Sea Cliff P.S. #1	18" dia.	1.8	2,484	4	3	0	.70	3	2.59	8	3.01	9	3.51	11	4.00	12	4.16	13	
16	Sea Cliff	6' dia.	28.3		566	17	02	.67	380	1.57	597	1.88	714	2.20	836	2.48	942	2.80	1,064	
17	Sea Cliff P.S. #2	12" dia.	0.8		8	4	0	.70	6	2.59	16	3.01	18	3.51	21	4.00	24	4.16	25	
18	Baker's Beach	7' dia.	38.5		1,412	20	28	.54	765	1.41	1,071	1.68	1,285	1.99	1,522	2.21	1,691	2.50	1,913	
	RICHMOND-SUNSET DISTRICT		390.8	10,391	9,004						6,461		7,641		8,992		10,120		11,265	
20	Baker Street	9' dia.	63.4	1,091	241	15	55	.60	145	1.60	232	1.95	283	2.29	332	2.57	373	2.88	418	
21	Pierce	8' dia.	50.3	447	447	15	40	.70	313	1.63	510	1.99	623	2.32	726	2.60	814	2.90	908	
22	Laguna	6' dia.	28.3	407	357	13	53	.70	250	1.72	430	2.10	525	2.50	625	2.79	698	3.10	775	
23	Hyde	24" dia.	3.1	38	36	7	11	.80	30	2.33	70	2.79	84	3.20	96	3.65	110	4.00	120	
24	Beach	6'x7'	41.1	314	314	12	52	.75	236	1.80	425	2.19	517	2.56	604	2.88	680	3.19	753	
25	Grant (Beach St. Relief)	36" dia.	7.1	20	20			.75	15.											
26	Sansome	2 @ 5'-6"x 6'-6"	69.5								Part of interconnected network.									
27	Greenwich	6' dia.	28.3	517	517	(13	20)	(.83)	(429)	(1.78)		(2.40)		(2.50)		(2.80)		(3.15)		
28	Jackson	8'x9'-6"	72.3																	
29	Howard	7' dia.	38.5	225	225	14	10	.85	191	1.72	329	2.10	401	2.45	468	2.78	531	3.10	592	
30	Brannan	7'6"x6'	36.0																	
34	North Side Fourth St.	6'-6" dia.	33.2																	
35	Fifth Street	7'-9"	47.2	5,110	5,110	(19	00)	(.77)	(3,935)	(1.47)		(1.78)		(2.09)		(2.34)		(2.61)		
36	North Side Sixth St.	6' dia.	28.3																	
37	Seventh & Division	3 @ 8'-3"x 9'-6"	224.2								Part of interconnected network.									
31	Townsend	2'x3'	6.0	59	22	5	38	.75	17	2.55	43	2.98	51	3.47	59	3.88	66	4.11	70	
32	Berry	15" dia.	1.2		7	5	24	.60	4	2.58	10	3.00	12	3.48	14	3.90	16	4.14	17	
33	Third Street	2'-6"x3'-9"	7.3		30	11	41	.75	23	1.90	44	2.28	52	2.65	61	3.00	69	3.35	77	
38	South Side Sixth St.	3'-6"x5'-3"	14.0	186	63	10	25	.65	41	2.00	82	2.40	98	2.80	115	3.16	130	3.50	144	
39	South Side Fourth St.	2'-6"x3'-9"	7.3		125	15	27	.60	94	1.65	155	2.00	188	2.35	221	2.60	244	2.90	273	
	NORTH POINT DISTRICT		972.3	8,416	7,516						2,330 (8,879)		2,834 (10,868)		3,321 (12,610)		3,731 (14,139		4,147 (15,768)	
40	Mariposa	6' dia.	28.3	226	226	11	42	.65	147	1.90	279	2.28	335	2.65	390	3.00	441	3.35	492	
41	20th St. (Beth. Shipyd - Flow Unk.)	24" dia.	3.1	45	9	6	00	.50	92	2.49	12	2.90	15	3.40	17	3.80	19	4.08	20	
42	North Side Third St.	3'x6"x5'-3"	14.0	279	153	19	43	.60		1.45	133	1.71	157	2.01	185	2.28	210	2.57	236	
43	Marin	8'x10'	74.7	1,410	1,410	25	31	.65	917	1.23	1,128	1.48	1,357	1.71	1,568	1.95	1,788	2.15	1,972	
44	Selby	3 @ 7'x10'	209.1	3,307	3,307	29	32	.65	2,150	1.12	2.408	1.33	2,860	1.56	3,354	1.76	3,784	1.96	4,214	
45	Rankin	5' dia.	19.6	66	66	18	28	.60	40	1.50	60	1.80	72	2.10	84	2.35	94	2.65	106	
46	South Side Third St.	2'-6"x3'-9"	7.3	63	57	14	29	.55	31	1.69	52	2.06	64	2.40	74	2.70	84	3.00	93	
47	Mendell	4' dia.	12.6	369	nil	8	00	.60												
48	Evans	6' dia.	28.3	667	260	34	13	.60	156	1.03	161	1.21	189	1.41	220	1.58	246	1.75	273	
49	Hudson	30" dia.	4.9		45	5	21	.60	27	2.58	70	3.00	81	3.50	95	3.95	107	4.15	112	
50	Griffith North	21" dia.	2.4		17	6	40	.60	10	2.39	24	2.81	28	3.29	33	3.69	37	4.02	40	
51	Griffith South	5'-6" dia.	23.8	551	182	19	06	.60	109	1.46	159	1.75	191	2.07	226	2.31	252	2.59	283	
52	Yosemite	9'x7'-3" 11'-6"x6'-6"	52.9 69.6	1,047	1,047	18	28	.60	628	1.50	942	1.80	1,130	2.10	1,319	2.35	1,476	2.65	1,664	
53	Fitch	6'9" dia.	35.8	350	121	14	24	.60	73	1.70	124	2.05	75	2.41	176	2.70	197	3.01	220	
54	Sunnydale	6'6" dia.	33.2	832	594	19	48	.55	327	1.43	468	1.72	562	2.01	657	2.28	746	2.56	837	
	S.E. COLLECTION SYSTEM		619.6	9,212	7,494						6,020		7,116		8,398		9,481		10,562	
	GRAND TOTAL		1,882.7	28,019	24,014						14,811 (21,360)		17,591 (25,625)		20,711 (30,008)		23,332 (33,740)		25,974 (37,595)	(GRAND TOTAL with Interconnected Network.)

REMARKS

(1) 12 Ac. of No. San Mateo not incl. Q_{5yr} = 7cfs.
(2) 75 acres to Mile Rock
(3) Incl. 504 acres G.G. Park & 494 acres Presidio.
(4) Incl. Ft. Miley 85 acres & G.G. Park 51 acres.
(5) 5 min. T_c used for computations
(6) Incl. 23 acres from G.G. Park.
(7) 5 min. T_c used for computations.
(8) Incl. 319 acres from G.G. Park.
(9) Incl. 850 acres from Presidio.
(10) (Fig.) = Total Q including estimated flow from interconnected network.
(11) 464 sewered acres of No. San Mateo not incl. Q_{5yr} = 338 cfs.
(12) Undeveloped area - Outlet not functioning.
(13) 135 sewered acres of No. San Mateo not incl. Q_{5yr} = 106 cfs.

Note:
(1) Refers to Outfall #11.
(2) Refers to Outfall #12.
(3) Refers to Outfall #13.
(4) Refers to Outfall #14.
(5) Refers to Outfall #15.
(6) Refers to Outfall #16.
(7) Refers to Outfall #17.
(8) Refers to Outfall #18.
(9) Refers to Outfall #20.
(10) Refers to NP District.
(11) Refers to Outfall #45.
(12) Refers to Outfall #47.
(13) Refers to Outfall #54.

TABLE II-15

PRESENT AND FUTURE ESTIMATED FLOWS TO DRY WEATHER TREATMENT PLANTS, MGD

Plant (Drainage District)	Present average day	Future* Dry Weather average day	Future* Dry Weather peak flow rates	Present Hydraulic Capacity
North Point	64.7	74	134	200
Southeast	19.2	24	57	70
Richmond-Sunset	21.1	27	54	70
Total	105.0	125	245	340

*Values projected for the year 2020

TABLE II-16

MASTER PLAN ESTIMATED FLOWS TO COMBINED WET WEATHER-DRY WEATHER TREATMENT PLANT[S], MGD

Plant (Drainage District)	Future* Wet Weather average	Peak Wet Weather
North Point	259	370
Southeast	177	305
Richmond-Sunset	188	325
Total	624	1,000

*Based upon median hourly wet weather rate plus future average dry weather flow

TABLE II-17
CITY & COUNTY OF SAN FRANCISCO
SEWERAGE SYSTEM
LAND USE DISTRIBUTION, POPULATION & EMPLOYMENT

SUMMARY FOR TOTAL CITY

AREA CLASSIFICATION	YEAR	LAND USE (% OF GROSS AREA)				GROSS AREA (ACRES)	HOUSING		POPULATION (NO. OF PERSONS)	EMPLOYMENT (NO. OF PERSONS)
		INDUSTRIES & MANUFACTURING	COMMERCIAL, TRANSPORTATION & UTILITIES	RESIDENTIAL	PUBLIC LANDS & ALL OTHERS		SINGLE FAMILY (NO. OF UNITS)	MULTI-FAMILY (NO. OF UNITS)		
MONITORED AREAS	1965	9.45	8.84	53.00	28.71	(23999)	104009	188504	706953	520300
	1990	10.15	13.51	45.54	30.80	(23999)	98231	219277	800283	773254
NON-MONITORED AREAS	1965	10.12	1.35	11.66	76.87	(4509)	2756	7723	33162	36364
	1990	11.35	3.34	9.90	75.41	(4509)	2656	7109	32807	49649
TOTAL AREA	1965	9.56	7.65	46.46	36.33	(28508)	106765	196227	740115	556664
	1990	10.34	11.90	39.90	37.86	(28508)	100887	226386	833090	822903

Reference 2 — Plate V-12

Figure II-1

TOPOGRAPHY OF SAN FRANCISCO

[Contour elevations in feet]

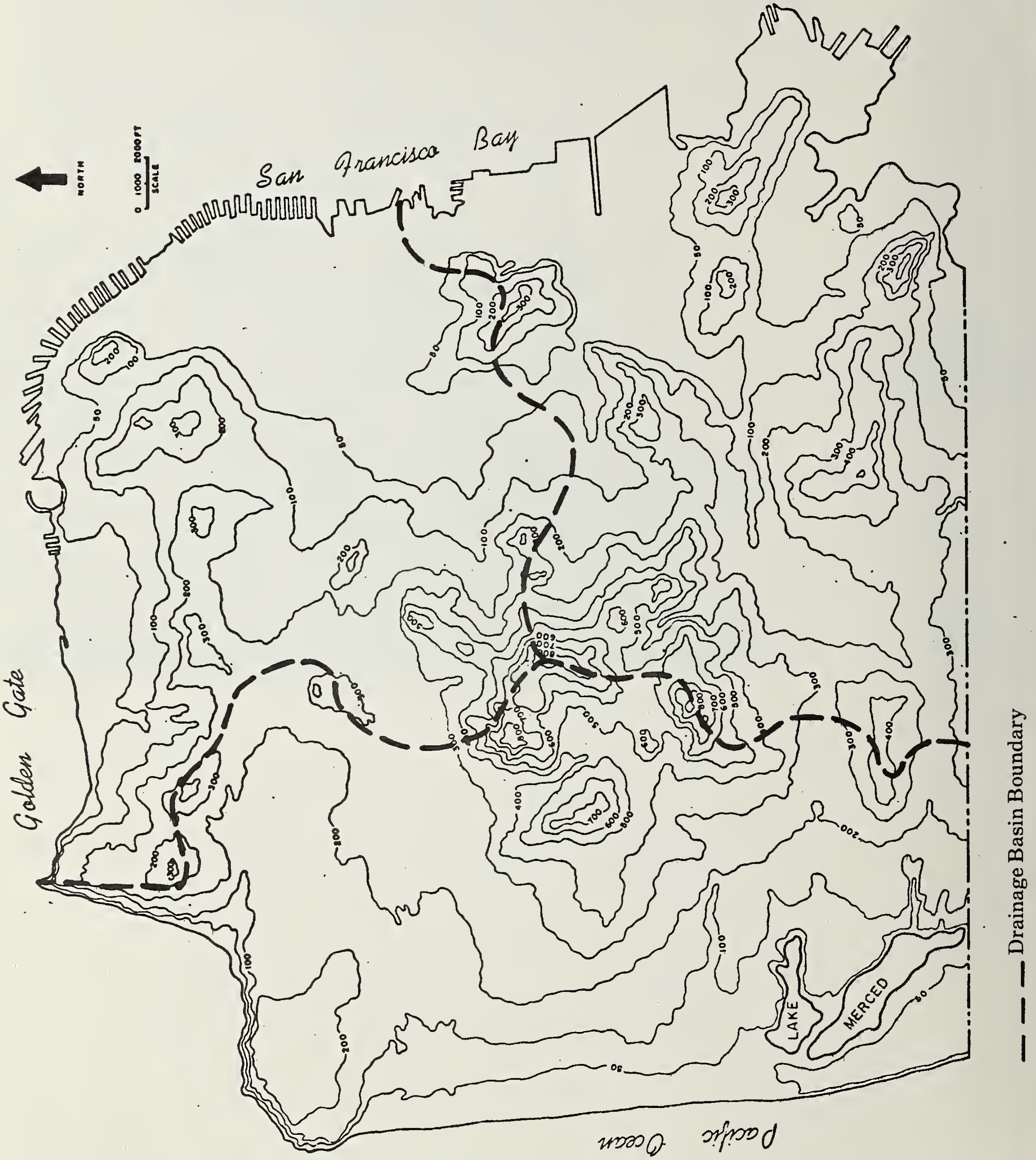


Figure II-2

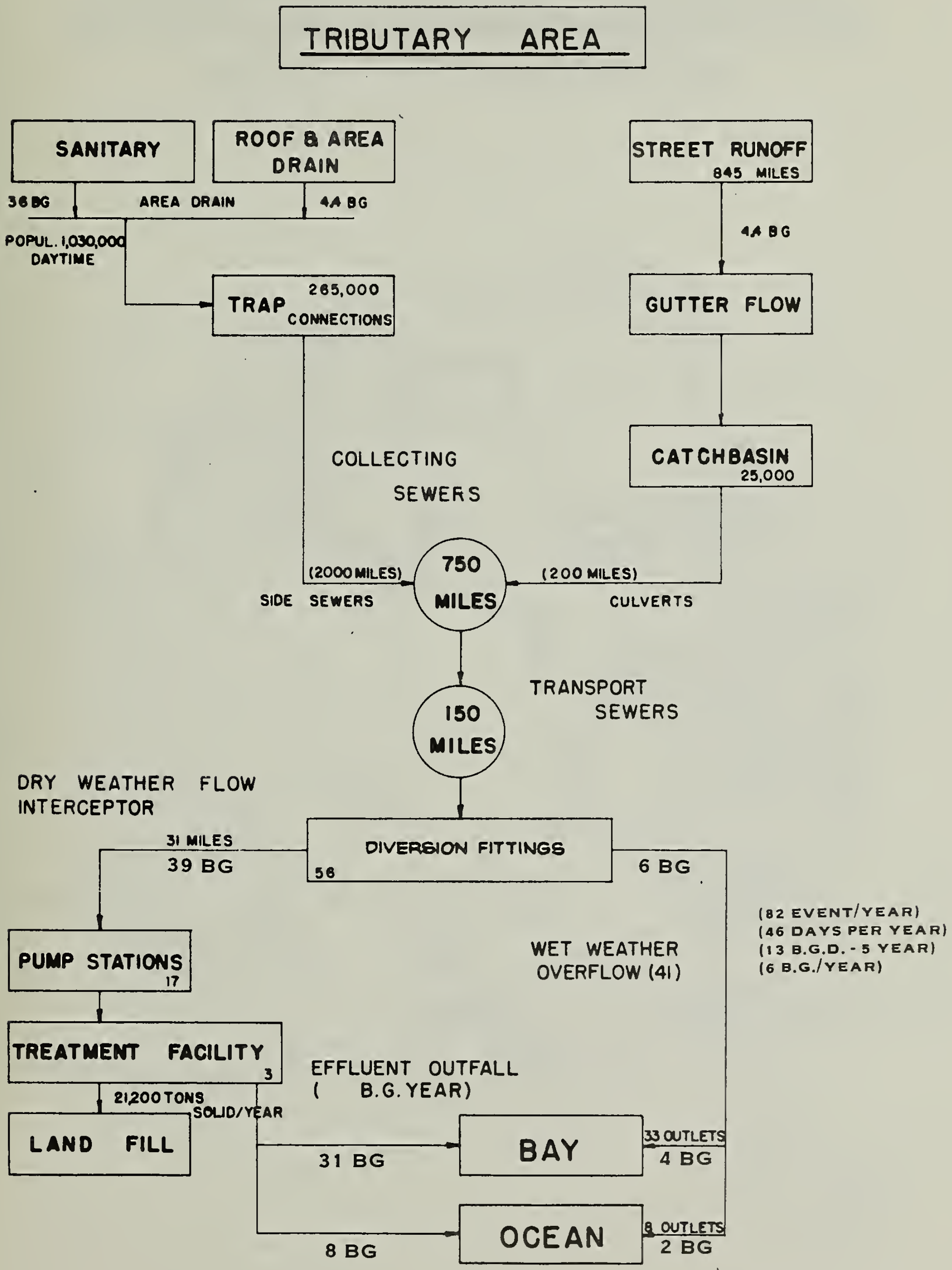

TRIBUTARY AREA
SANITARY
ROOF & AREA DRAIN
STREET RUNOFF
845 MILES
36 BG
AREA DRAIN
4.4 BG
4.4 BG
POPUL. 1,030,000
DAYTIME
TRAP
265,000 CONNECTIONS
GUTTER FLOW
COLLECTING SEWERS
CATCHBASIN
25,000
(2000 MILES)
SIDE SEWERS
750 MILES
(200 MILES)
CULVERTS
TRANSPORT SEWERS
150 MILES
DRY WEATHER FLOW INTERCEPTOR
31 MILES
39 BG
DIVERSION FITTINGS
56
6 BG
(82 EVENT/YEAR)
(46 DAYS PER YEAR)
(13 B.G.D. - 5 YEAR)
(6 B.G./YEAR)
PUMP STATIONS
17
WET WEATHER OVERFLOW (41)
TREATMENT FACILITY
3
EFFLUENT OUTFALL
(B.G. YEAR)
21,200 TONS SOLID/YEAR
LAND FILL
BAY
31 BG
33 OUTLETS
4 BG
OCEAN
8 BG
8 OUTLETS
2 BG

Figure II-3

CITY & COUNTY OF SAN FRANCISCO LOCATION OF ADEQUATE & INADEQUATE MAJOR TRANSPORT SEWERS

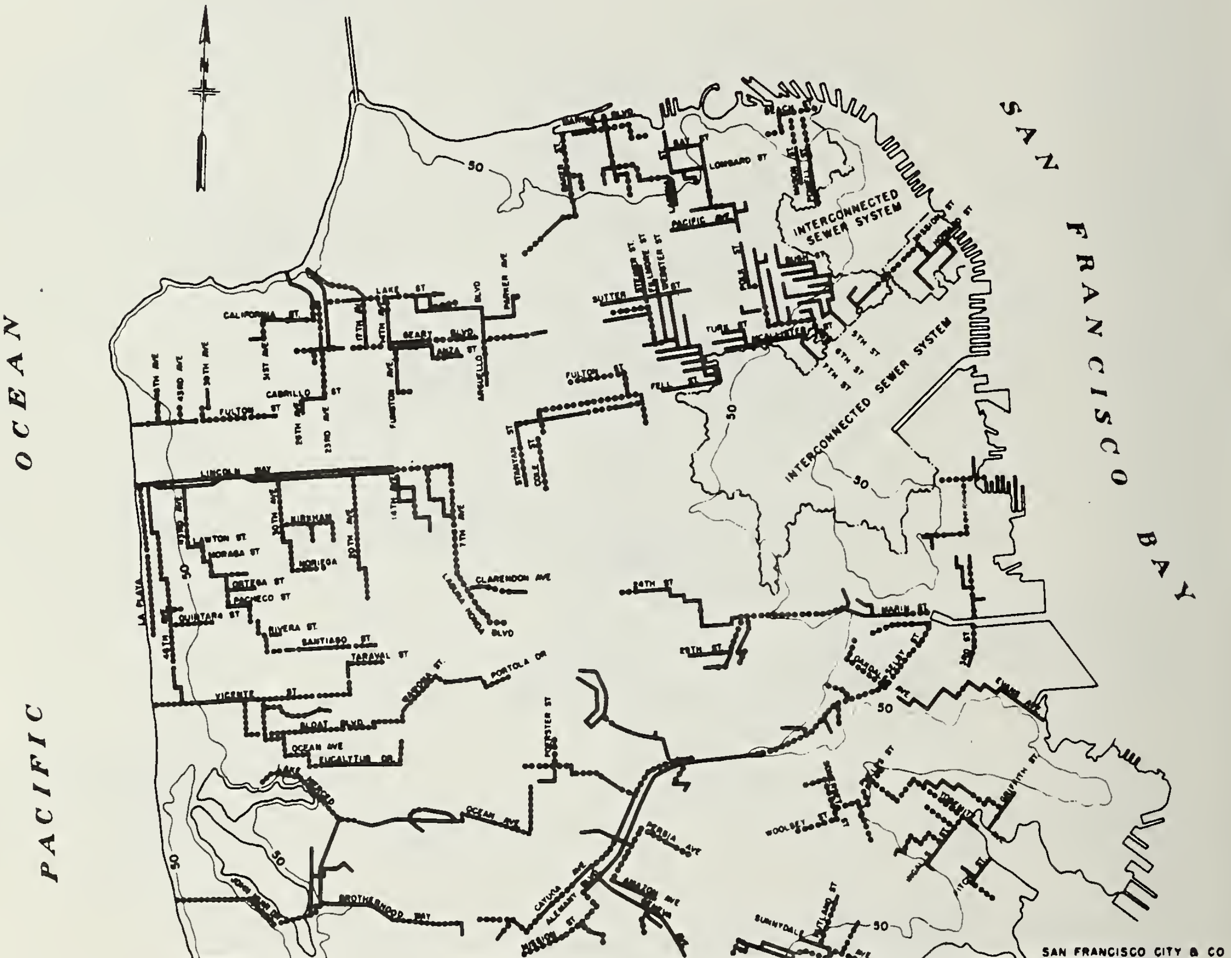


Figure II-4

CITY & COUNTY OF SAN FRANCISCO LOCATIONS OF INTERCEPTING SEWERS AND PUMP STATIONS

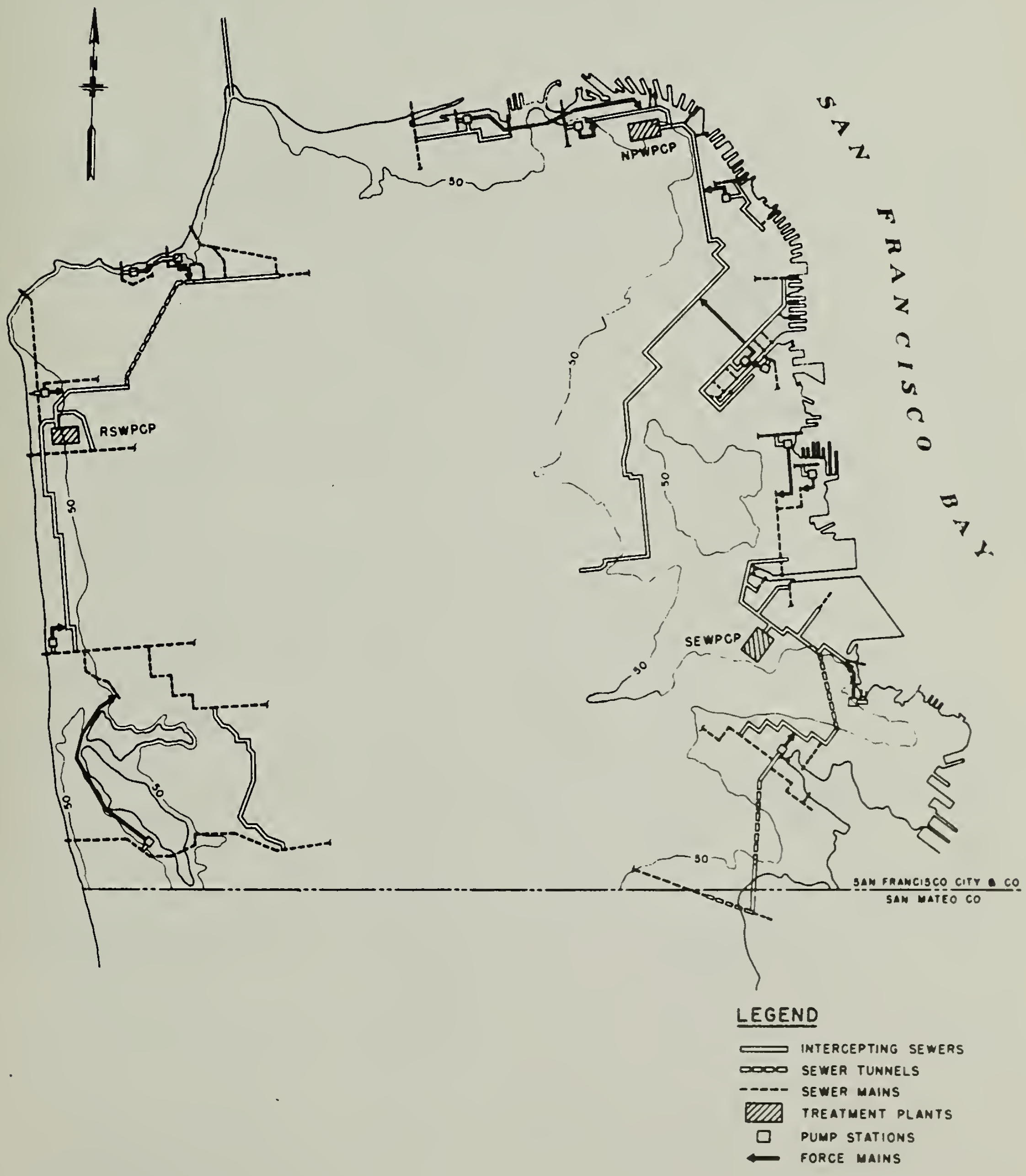


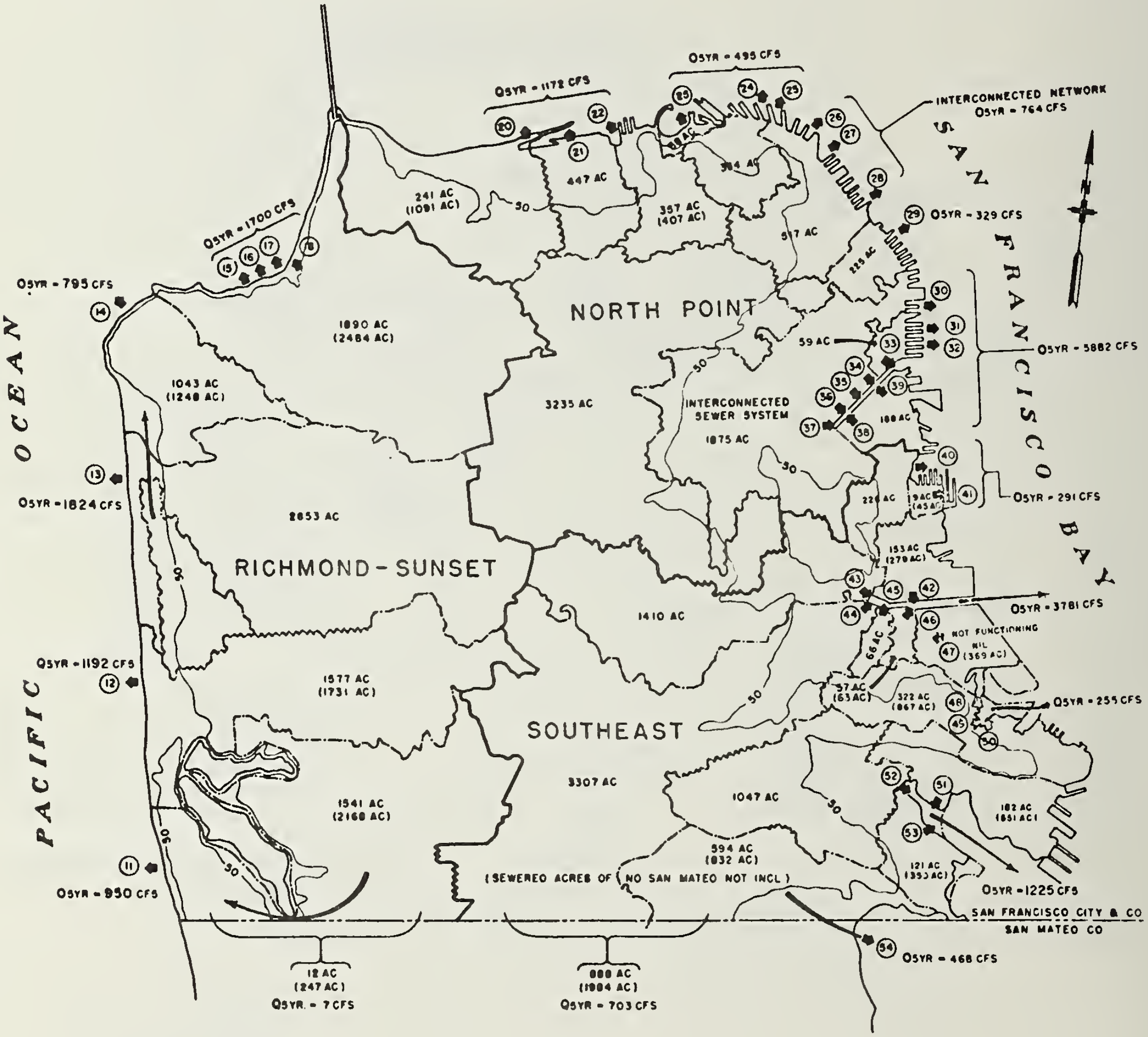
Figure II-5

LOCATIONS OF BYPASS STRUCTURES

SUMMARY

OCEAN	BAY
SEWERED ACREAGE = 9,000	SEWERED ACREAGE = 15,000
TRIBUTARY ACREAGE = 10,400	TRIBUTARY ACREAGE = 17,600
STORM FLOW (5YR.) = 6,500 CFS	STORM FLOW (5YR.) = 15,000 CFS *

* INCLUDES ESTIMATED FLOW OF 6,500 CFS FROM INTERCONNECTED SEWER SYSTEM.



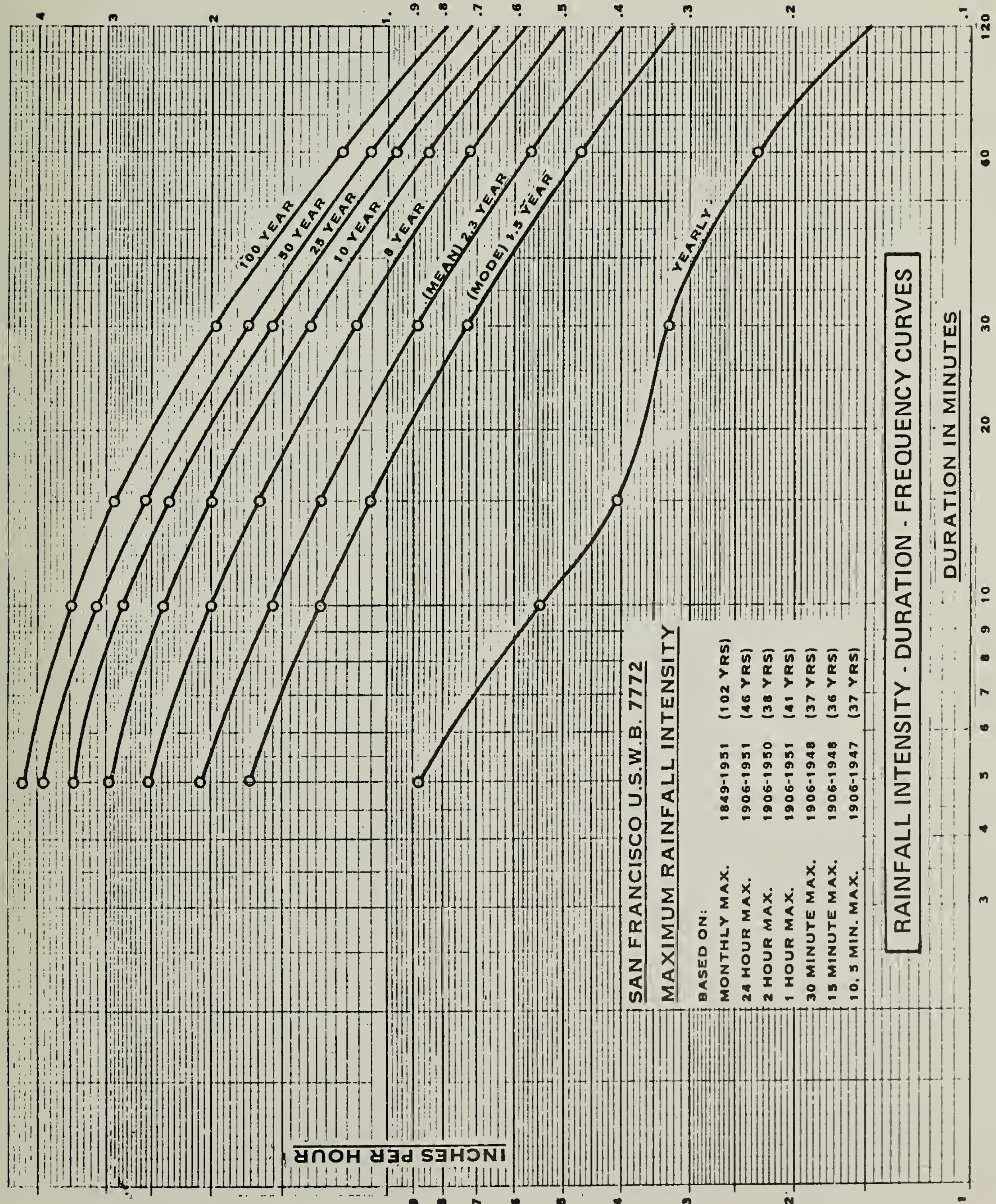
LEGEND

FIG	SEWERED ACREAGE
(FIG.)	TRIBUTARY ACREAGE
➡	OUTFALL
⑫	OUTFALL NO.

NOTE: AREAS WHERE ONLY ONE SET OF FIGURES IS SHOWN INDICATES SEWERED AND TRIBUTARY ACREAGES ARE THE SAME.

Figure II-6

RAINFALL INTENSITY DURATION FREQUENCY CURVES



Chapter III

WASTE QUALITY

The quality of wastewater directly influences the treatment needed to produce the desired effluent quality. Wastewaters from the City must be characterized to determine the level of treatment necessary to remove deleterious substances and to determine the emission rates of these substances with alternative management and treatment methods. From information on the emissions from various treatment alternatives, effect of these emissions on the receiving waters, and costs of the alternatives, the cost effectiveness relationships can be developed and used in selecting the optimum management system.

SANITARY SEWAGE [DRY WEATHER FLOW]

Sanitary sewage normally includes household wastes from bathroom, kitchen, and laundry along with industrial process wastes and various wastes from commercial operations. The general quality range for this type of waste, as well as diurnal and annual quality variations, are well documented. The quality of a waste of this type is generally not highly variable.

Monitoring programs conducted by the City at the three sewage treatment plants provide information which extends over many years but is limited to only a few parameters. Data include suspended solids, grease, and 5-day BOD levels for the period from July 1969 through December 1970.

Data have also been gathered in conjunction with engineering studies sponsored by the City. The most comprehensive of the sanitary waste characterizations was conducted by Brown & Caldwell Engineers during evaluation of the existing treatment facilities (Ref. 18). Intense sampling and testing for one week at each of the treatment plants during July, August, and September of 1970 produced data on numerous parameters.

Engineering-Science, Inc., has twice characterized sanitary wastes from San Francisco drainage basins. The first was related to a study of combined sewer overflows during three months in 1966 and 1967 (Ref. 3). This study yielded quality information for sanitary waste from the Selby Street and Laguna Street drainage basins. A similar study conducted in 1969 and 1970 produced quality data for the Baker Street, Brotherhood Way, and Mariposa Street drainage basins (Ref. 11). The available information is summarized in Table III-1.

The available data describing sanitary waste are sufficient for definition of the problem and evaluation of conceptual alternatives. It is recognized in the Master Plan that design of the waste treatment systems cannot proceed without further detailed information.

COMBINED SEWAGE

Combined sewage is the wastewater which results when sanitary waste and stormwater runoff are mixed in a combined sewer system. The quality of this waste is highly variable depending to a large extent on the quality and quantity of the stormwater runoff. Other factors such as rainfall intensity which results in scouring of the sewers caused by high flow rates also affect waste quality.

The only sources of data on the quality of combined waste from San Francisco are the two previously mentioned studies conducted by Engineering-Science, Inc. During these studies, the combined waste quality was monitored for eight storms in the Selby Street Basin, two storms in the Laguna Street Basin, and three storms each in the Baker Street, Mariposa Street, and Brotherhood Way Basins. Figure III-1 shows typical plots of pollutant concentration versus time for combined sewage and the associated rainfall and flow rate. The high concentrations during the early runoff followed by a gradual decrease in pollutant content is typical of the data gathered for San Francisco and for other combined sewer systems. Quality data for the combined sewage discharged from these 19 storm-basin observations are summarized in Table III-2.

Sufficient data exist to characterize combined sewage for all appropriate parameters except conservative toxicants such as pesticides and heavy metals. A recent study conducted for the Environmental Protection Agency (Ref. 32) found that significant amounts of pesticides and heavy metals accumulate on street surfaces where they are subject to removal by storm runoff. Information on the quality of combined sewage with respect to these parameters should be obtained to facilitate selection of the appropriate treatment alternative.

The Master Plan Report concludes that "Level I" treatment is sufficient for treatment of wet weather flows. It is reasonable to assume that chemical primary treatment, or some other modified primary system designed for efficient high rate removal of floatable and settleable solids, is the maximum level that could reasonably be utilized for the high rate flows occurring during storms. However, the available information does not permit a determination of effluent quality compliance with State regulations. Source control is an effective and preferable method of limiting the content of some conservative toxic substances in sanitary waste. Regulation of industrial inputs can be effective. Source control by improved street cleaning methods may be practical for controlling materials contained in storm runoff.

Available quality data for sanitary waste and combined sewage show the waste to be similar in characteristics to that from other communities. Data from other communities characterizing the quality of stormwater runoff could be utilized in estimating runoff quality for San Francisco; however, the information provided would not modify the conclusions or affect the Master Plan concept.

STORMWATER RUNOFF

The quality of stormwater runoff is dependent on the quantity of the rainfall, on the availability, nature and magnitude of material accumulated on surfaces washed by rainfall, on characteristics of the surface, and on the intensity of rainfall and resultant velocity of runoff flow.

The data on stormwater runoff from San Francisco is limited by the lack of separated sewer systems. Only the Vincente Street drainage basin has a separate sewer system for stormwater flows. Engineering-Science, Inc., monitored runoff from each of two sub-basins within the Vincente Street drainage basin on one occasion in February 1970. Quality information gathered during this effort is summarized in Table III-3.

The physical structure of San Francisco's sewer system precludes adequate characterization of stormwater runoff by direct measurement. The information derived from sanitary sewage and combined sewage data is sufficient for the purpose of conceptual master planning.

Engineering-Science, Inc., has developed net emission curves (Ref. 11-Fig. V-29) to predict storm runoff emissions for various parameters. The curves were used extensively in the Master Plan for determining "due to storm" emissions. Preliminary investigation of these curves has revealed that they may not be representative of the data on which they are based. Analysis of the curves for COD and TSS indicates that the "due to storm" emissions reported may be up to twice the amount which can be justified from the data.

MASS EMISSION RATES

Table III-4 shows the relative potential mass emissions to the Bay and ocean water from sanitary sewage and combined waste waters. Combined wastes appear to contribute a significant percentage of the suspended solids and floatables. The relative quantities contained in combined waste for the other parameters is less than 10 percent of the total raw mass emissions in all cases.

Information is not available from which to calculate mass emission rates for storm or combined discharges of heavy metals or pesticides.

The pollutant emissions which can be discharged at any point without adverse effects are determined primarily by the effect of the pollutant on the receiving water. The acceptable level of discharge is dependent on the waste constituent being considered and the duration of emission. Generally receiving waters can tolerate greater rates of discharge of pollutants for short time periods without adverse effects than on a continuous basis. Determination of acceptable emission rates for various frequencies and durations of overflows and continuous discharge will define the treatment efficiencies needed to provide protection of the receiving waters. The selection of treatment and storage needs is dependent upon a determination of acceptable emission rates and their frequency for the significant parameters. All emission information is of necessity derived by calculation from measured quality and quantity data. The validity of emission data is therefore dependent on the validity of quality and quantity data as being representative of actual storm conditions.

Available information is sufficient to determine the relative importance of combined waste with regard to mass emission rates and make it evident that annual new mass emissions of substances contained in combined waste are of less concern than sanitary sewage emissions. For some parameters the mass emission is less with existing control facilities than that which would be discharged by a separated sewer system. The effects of the emissions with current facilities, however, may be significant.

It is important to recognize the differences in characteristics of storm and sanitary waste material, particularly for floatables. The storm water floatables consist largely of trash particles whereas sanitary floatables are mainly fecal matter and grease and oil which is far more objectionable. Also, the solids portion of sanitary sewage generally contains a higher percentage of organic matter than solids contained in storm water. The data do not clearly describe the nature of floatables and solids contained in bypassed waste. Although not easily quantified, this information would more clearly show the need for control of wet weather bypassing.

The emission data are sufficient for a definition of the problem, evaluation of alternatives, and development of a master plan. The data are adequate to clearly show a need for major improvements to comply with existing and anticipated policies and regulations of the State and Federal government. Additional information characterizing bypassed floatables would only clarify and show the magnitude of the problem more precisely.

TABLE III-1

MEAN QUALITY OF RAW SANITARY SEWAGE FROM THE CITY OF SAN FRANCISCO

Parameter	Units	DATA SOURCE Brown & Caldwell (2)	Treatment Plant Monitoring (3)	Engineering-Science, Inc. (4)
PHYSICAL CHARACTERISTICS				
Floatables	mg/l	2.8		3.4
Settleable Solids	ml/l/hr	12.3		
Suspended Solids				
Total	mg/l	270	202	192
Volatile	mg/l	240		146
Turbidity	JTU	57		
CHEMICAL CHARACTERISTICS				
BOD (5-day)	mg/l	220	220	173
COD	mg/l	550		435
Grease & Oil (HEM)	mg/l	65	63	44
Nitrate as N	mg/l	2.75		
Nitrite as N	mg/l	0.13		
Nitrogen (Ammonia)	mg/l	17		8.6
Nitrogen (Organic)	mg/l	20		
Nitrogen (T. Kjeldahl)	mg/l	38		30
Phenols	mg/l	0.08		
Phosphate (Ortho)	mg/l	22		26
Phosphorous (Total)	mg/l	31		
Metals				
Aluminum	mg/l	8		
Arsenic	mg/l	0.0097		
Cadmium	mg/l	0.02		
Chromium (Total)	mg/l	0.42		
Copper	mg/l	0.185		
Iron (Total)	mg/l	1.85		
Lead	mg/l	0.160		
Mercury	mg/l	0.045		
Nickel	mg/l	0.015		
Silver	mg/l	0.007		
Zinc	mg/l	0.39		
TICH	ug/l	0.59		
MBAS	mg/l			
BIOLOGICAL CHARACTERISTICS				
Coliform Organisms	MPN/100 mls			2.9×10^7 (median)
Fecal Coliform	MPN/100 mls			2.3×10^6 (median)[6]
Toxicity				
Med. Tolerance 96 hr. (5)	%	66		
% Survival 96 hr. (5)	%	17		

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[1] Flow weighted means

[2] Reference No. 18

[3] Appendix Section 2, Tables IV-7,9

[4] References No. 3 and 11

[5] Stickleback test fish

[6] Baker Street, Mariposa Street, and Brotherhood Way only.

TABLE III-2

QUALITY OF COMBINED SEWAGE FROM THE CITY OF SAN FRANCISCO [1][2]

Drainage Basin		North (3) Point	Southeast (4)	Richmond- (5) Sunset	Range of Mean Storm Concentrations	Range of Sample Concentrations
Parameter	Unit					
PHYSICAL CHARACTERISTICS						
Floatables	mg/l	2.6	3.8	14	0.57-496	0.1-1415
Settleable Solids	ml/l	4.0	4.9	2.9	0.7-71	0.1-145
Suspended Solids						
Total	mg/l	105	216	504	63-1960	15-5540
Volatile	mg/l					
Turbidity	JTU					
CHEMICAL CHARACTERISTICS						
BOD (5-day)	mg/l	36	60	51	10-254	2-480
COD	mg/l	146	191	151	64-819	16-12800
Grease and Oil	mg/l	16	18	43	3.2-109	0.1-1327
Nitrate-N	mg/l					
Nitrite-N	mg/l					
Nitrogen (Ammonia)	mg/l	4.4	3.1	2.6	0.57-18	0-23.8
Nitrogen (Organic)	mg/l					
Nitrogen (Total Kjeldahl)	mg/l	5.8	7.5	20	2.0-42	0.35-71
Phenols	mg/l					
Phosphate (Ortho)	mg/l	0.9	2.2	2.0	0.54-9.5	0.2-15.4
Phosphorous (Total)	mg/l					
Metals						
Aluminum	mg/l					
Arsenic	mg/l					
Cadmium	mg/l					
Chromium (Total)	mg/l					
Copper	mg/l					
Iron (Total)	mg/l					
Lead	mg/l					
Mercury	mg/l					
Nickel	mg/l					
Silver	mg/l					
Zinc	mg/l					
TICH	mg/l					
MBAS	mg/l					
BIOLOGICAL CHARACTERISTICS						
Coliform Organisms	MPN/100 mls					
Fecal Coliform Organisms	MPN/100 mls					
Toxicity						
Median Tolerance Limit (96 hr) (6)	%	>100			86->100	
Percent Survival (6)	%	100			0-100	

(1) Base data from Ref. 3 and 11

(2) Volume weighted mean

(3) Based on data from Baker St. & Laguna St. Basins

(4) Based on data from Selby St. & Mariposa St. Basins

(5) Based on data from Brotherhood Way Basin

(6) Stickleback test fish

TABLE III-3

QUALITY OF STORM RUNOFF FROM VICENTE STREET SUB-BASIN – CITY OF SAN FRANCISCO [1]

PARAMETER	UNIT	MEDIAN	MEAN(2)	RANGE	NUMBER OF SAMPLES
PHYSICAL CHARACTERISTICS					
Floatables	mg/1	3.0	3.4	1.0-7.4	16
Settleable Solids	ml/1	0.38	0.57	0.09-5.7	16
Suspended Solids					
Total	mg/1	33	49	11-210	20
Volatile	mg/1	18		5-77	20
Turbidity	JTU				
CHEMICAL CHARACTERISTICS					
BOD (5-day)	mg/1	6.2	9.1	1.4-98	16
COD	mg/1	57	67	27-428	20
Grease & Oil	mg/1	10.5	10	4.5-21.5	15
Nitrate	mg/1				
Nitrite	mg/1				
Nitrogen (Ammonia)	mg/1	0.24	0.38	< 0.01-4.84	
Nitrogen (Organic)	mg/1				
Nitrogen (Total Kjeldahl)	mg/1	1.32	1.5	0.56-8.5	16
Phenols	mg/1				
Phosphate (Ortho)	mg/1	0.10	0.12	0.02-1.25	16
Phosphorous (Total)	mg/1				
Metals					
Aluminum	mg/1				
Arsenic	mg/1				
Cadmium	mg/1				
Chromium (Total)	mg/1				
Copper	mg/1				
Iron (Total)	mg/1				
Lead	mg/1				
Mercury	mg/1				
Nickel	mg/1				
Silver	mg/1				
Zinc	mg/1				
TICH	ug/1				
MBAS	mg/1				
BIOLOGICAL CHARACTERISTICS					
Coliform Organisms	(MPN/100 mls)	$2.3\text{x}10^5$		$(0.43\text{-}43)\text{x}10^5$	16
Fecal Coliform Organisms		$6.3\text{x}10^4$		$(<0.3\text{-}230)\text{x}10^4$	16
Toxicity					
TL 96(3) 50	%				
Percent Survival (3)	%	60		0-100	

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(1) Base data from Reference 11

(2) Volume weighted mean

(3) Stickleback test fish

TABLE III-4

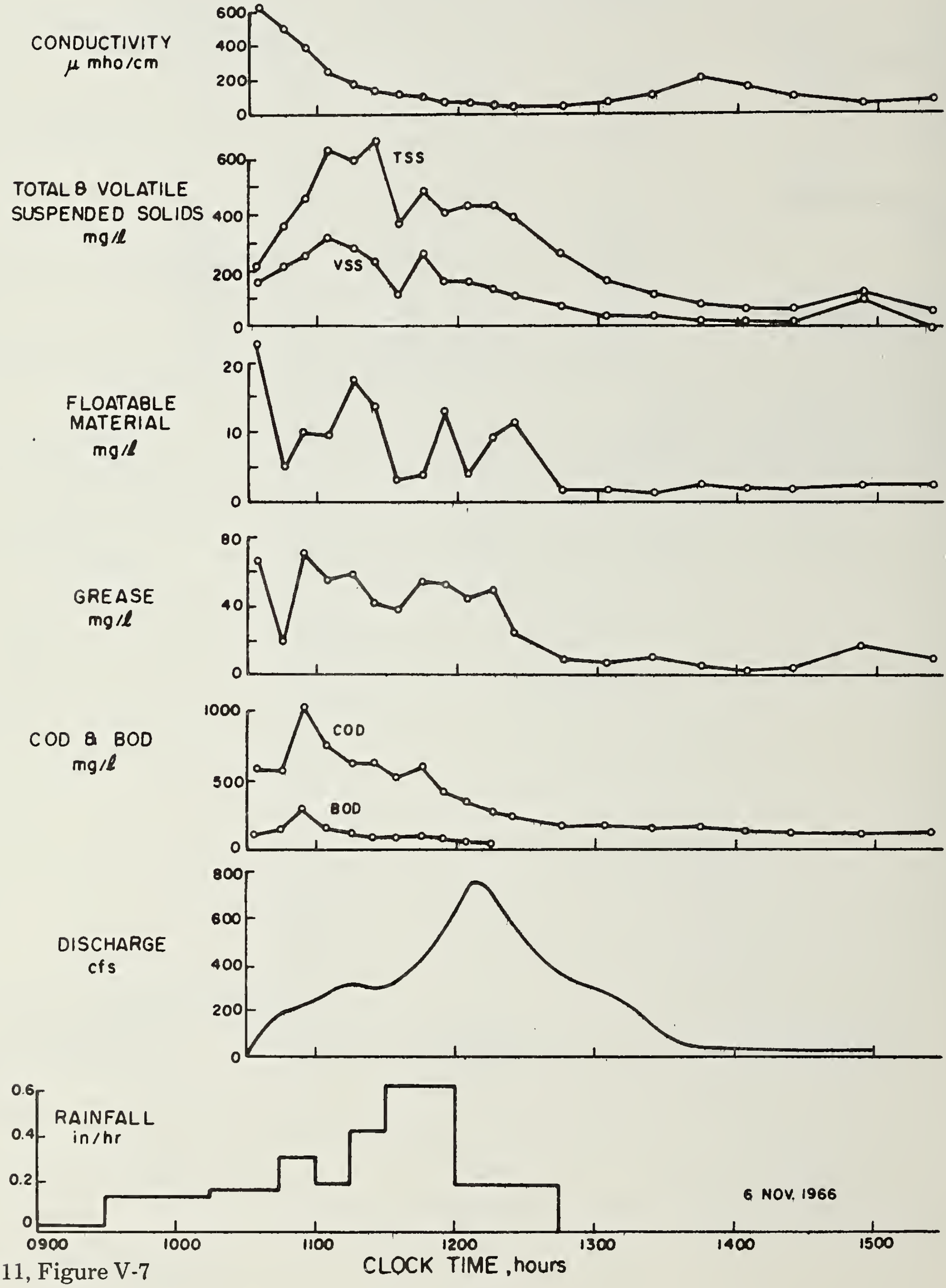
RAW WASTEWATER CONSTITUENT LOADINGS[1]

Parameter	Sanitary Waste(2) Million Pounds Per Year	Sanitary Waste(2) Percent of Total	Combined Waste(3) Million Pounds Per Year	Combined Waste(3) Percent of Total
Physical Characteristics				
Floatables	0.73	57	0.54	43
Suspended Solids				
Total	58.4	73	21.3	27
Chemical Characteristics				
BOD (5-day)	69.8	95	3.7	5
COD	136.7	92	11.9	8
Grease & Oil	19.8	91	1.9	9
Nitrogen (Total Kjeldahl)	9.4	91	0.9	9
Phosphate (Ortho)	7.1	98	0.12	2

(1) With chemical addition treatment
(2) With conventional primary treatment
(3) Combined storm and sanitary wastewater

FIGURE III-1

CHARACTERISTICS OF RAINFALL AND COMBINED SEWER OVERFLOW, SELBY STREET



Reference 11, Figure V-7

Chapter IV

RECEIVING WATER ANALYSIS

In this chapter, information on the receiving waters into which San Francisco discharges its wastewaters is presented. This information includes general physical characteristics, water quality conditions, and ecological data on the Central California coast, Gulf of the Farallones, Central Bay, and South Bay.

Prior to the development of a waste management plan, the alternative discharge points must be analyzed to determine the area where a discharge will have the least environmental impact. This includes an evaluation of the physical, chemical, and biological ability of the Bay and ocean waters to accept wastewater without unacceptable change. This requires a description of the mass water movement, currents, and surface drift; a description of the water quality conditions; and an inventory of the marine ecosystem and its tolerance to treated wastewaters. Once this information has been obtained and analyzed, the type of treatment can be selected that provides adequate protection of marine resources and obtains the maximum advantage of natural receiving water characteristics.

WATER CURRENT PATTERNS

Central California Coast

Prevailing ocean currents off the coast near San Francisco are characterized by two major currents. In the winter months during the rainy season, the prevailing nearshore current is the northerly Davidson Current. This is followed in the spring, summer, and fall by the southerly California Current.

The influence of these currents is diminished in the nearshore zone east of the Farallones where tidal exchange with the Bay overrides the effect of the offshore currents. Bay waters which move west and south from the Farallones during ebb tides are entrained in these prevailing ocean currents and soon become intermixed with the ocean water.

Gulf of the Farallones

Oceanographic characteristics of the Gulf are largely dependent upon the tidal ebb and flood flow through the Golden Gate which varies in magnitude with the season.

Wet Weather Mass Water Movement — During winter periods of maximum Delta outflow, the less dense Bay water produces a tidal outflow which occurs primarily as a surface layer. It extends up to 15 miles west and 10 miles south of the Golden Gate before becoming entrained in the ocean currents. At times of high Delta outflow the surface flow may ebb continuously and surface flood tides are almost nonexistent. Most of the flooding tidal prism consists of dense bottom ocean water entering the Bay from the north through Bonita Channel and from the south around Lands End.

Wet Weather Currents — Current velocity and direction during the winter season vary dramatically with depth following the stratification developed in the tidal waters. A surface layer of 10 to 15 feet moves westward and southward with current speeds of 2 to 4 knots. Immediately below this layer there exists a more balanced pattern of ebb and flood currents of lesser speeds. Low speed flood currents predominate near the bottom.

Dry Weather Mass Water Movement — In the absence of stratification during the summer and fall, the same general movement southward and westward by the ebbing surface layer still exists. During this period of minimum Delta outflow, tidal outflow is decreased and the net surface movement is much smaller. The ebbing tide now extends westward to the chipping channel and southward to a point west of Lake Merced.

As before, the flooding tidal prism consists primarily of flow along the shore north and south of the Gate. Under minimum outflow conditions there is an eastward movement of surface water toward the Gate but of a lesser displacement than exists in the bottom water.

Dry Weather Currents — Surface currents are in phase with, but of a greater magnitude than, bottom currents during the ebb; and bottom currents are greater during flood tides. This results in a net surface displacement away from the Gate with bayward movement predominant near the ocean bottom. Current speeds are greatest near the Golden Gate but seldom exceed one knot outside the bar.

Central Bay

The volume of the tidal prism is so large that it overrides the influence of even the Delta inflow. As a result, although the pattern of mass water movement is modified somewhat, the basic flow patterns remain unchanged throughout the year.

Mass Water Movement — From the Bay Bridge through Alcatraz Channel, there is a pronounced net seaward displacement of the surface layer and a southerly bayward flow of bottom waters. Surface displacement is much greater than that found on the bottom indicating the shallowness of the faster moving top layer. During wet weather conditions, a surface displacement of 10 to 25 nautical miles per tidal cycle is evidenced. This would result in a mean Bay retention time for a surface field released near Alcatraz of less than 12 hours. This net seaward displacement still exists under dry weather conditions but subsides to several nautical miles per tidal cycle during the period of low Delta inflows.

Currents — In the Alcatraz Channel, current direction for both ebb and flood tide is approximately parallel to the shoreline. Maximum velocity for surface currents commonly exceeds 3 knots with occasional 4-knot velocities. Greater velocity exist on the ebb tide but are of shorter duration than the flood tide currents. Maximum bottom velocities are generally less than 2 knots.

Tidal Exchange — The ratio of new ocean water entering the Bay with each flood tide to the total tidal prism, the tidal exchange ratio, varies with the amplitude of the flood tide. Based on an average tidal amplitude of 4.1 feet, a dry weather tidal exchange ratio at the Gate of approximately 24 percent exists. For each 25-hour tidal cycle, this means an introduction of 20 to 30 billion cubic feet of new ocean water through the Golden Gate into the Bay with approximately 15 to 25 billion cubic feet passing through the Alcatraz Channel south of Alcatraz and the remainder flowing into the North Bay.

During wet weather conditions, fresh water inflow from the Delta and other tributaries into the Bay and out through the Gate increases the magnitude of new water flowing through the Bay. It is estimated that the total tidal exchange during large fresh water inflow exceeds 80 percent.

Surface Drift — Release of cardboard floats by Brown & Caldwell during the oceanographic studies in the Alcatraz Channel in June and October of 1970 indicate the general surface drift for this region. It was found that release of floatables near Alcatraz results in their accumulation on the ocean beaches north and south of the Golden Gate with no significant accumulation on the Bay shoreline. Floatables released outside the Gate during different tidal conditions will not enter the Bay.

These findings were verified by the oil spill that occurred near Alcatraz in January 1971. Oil contamination was concentrated mainly on ocean beaches outside the Bay with shoreline contamination inside the Bay limited to a small area seaward of the release point.

Surface drift studies by U. S. Geological Survey in March 1970 through April 1971 further substantiated this general observation of surface water movement. Central Bay surface drift was seaward for the entire study period. It was also found that no surface drifter released seaward of the Golden Gate was recovered within the Bay system.

South Bay

Mass Water Movement — South of the Bay Bridge to Hunters Point there is a net seaward flow on the surface and a net southerly flow on the bottom. The net surface seaward displacement south of the Bay Bridge is substantially less than that of the Central Bay and amounts to several nautical miles per tidal cycle in the waters adjacent to Hunters Point.

South of Hunters Point the tides create a counter-clockwise circulation in the South Bay. This can be attributed to the deep navigation channel on west side and broad shallow areas on the east side.

Currents — Direction of currents is similar to the pattern of mass water movement described above. During both ebb and flood tides current direction is generally parallel to the shoreline.

Surface Drift — Data available from current U. S. Geological Survey surface drift studies in March 1970 through April 1971 and earlier studies by the San Francisco Department of Public Works in September-October 1958 indicate the general surface drift for the northern part of South Bay. Release of surface drifters just south of Yerba Buena Island resulted in their displacement seaward out through the Golden Gate.

Nearshore Zone

Superimposed upon the general mass water movement for the Bay and the Gulf is the more complex region of water movement found in a zone extending approximately 500 to 1,000 feet off the shoreline of the peninsula. In this zone the current direction and speed varies from the general pattern described above. Friction from the shoreline and shoreline geometry produce eddies which vary in magnitude and direction with each tidal exchange and stage. The effect of this nearshore condition is to limit the exchange of water between prevailing offshore masses and that in the nearshore zone. This increases nearshore discharge retention times in the Bay considerably over that for a discharge further offshore.

RECEIVING WATER CONDITIONS

A summary of the proposed and existing outfall locations and general receiving water conditions in the water adjacent to the outfall are summarized in Tables IV-1 and IV-2, respectively. The effects of each discharge upon receiving waters are evaluated in this section.

Dissolved Oxygen

Depression of dissolved oxygen from waste discharge at each location is not a critical factor. Initial dilution capability for each outfall in combination with the fact that oxygen levels in the waters of the Gulf and Central Bay are near saturation should minimize problems associated with depression of oxygen levels. Mathematical model studies performed by Brown and Caldwell in 1969 indicated that the maximum depletion of oxygen in the Bay resulting from all San Francisco discharges would occur south of the Bay Bridge in the vicinity of the Southeast plant and would be approximately 0.07 mg/1. Although not significant, a submerged discharge at the Southeast location has the greatest potential of the outfall locations of depressing oxygen concentrations.

Nutrients

It was concluded in the Bay-Delta Report by Kaiser Engineers in 1969 that total nitrogen and phosphorous concentrations in Bay waters are substantially higher than the growth-limiting concentrations for either. Enrichment is observed mainly along the shores and in the tidal reaches of some of the tributaries. A possible explanation for lack of excessive algal production is light availabiltiy and the presence of toxic or inhibitory components from wastewater. Projected controls of Delta waters could significantly reduce turbid fresh water inflows to the Bay and result in increased available light. In addition, control of toxic materials in wastewater discharges should improve. This expected control will create conditions more favorable to algal production and could result in increases in algal growth. The net southward movement of a submerged field at the Southeast plant could result in a slight increase in South Bay nutrient concentrations from that discharge point.

Coliform Concentration

Beaches on the San Francisco peninsula shoreline are posted by the San Francisco Department of Public Health from October to April each year due to the contamination from waste discharges. Maximum coliform levels were attained during the rainy season and can be attributed to wet weather overflow of combined sewage. Figure IV-1 summarizes the coliform data from samples collected from 1967 through 1972. The plate shows that Public Health criteria for salt water bathing are normally exceeded throughout the shoreline waters surrounding the City during the entire winter season. In the vicinity of the dry weather outfalls, bathing standards are usually exceeded throughout the year with the exception of the Richmond-Sunset area where standards are normally met in July and August.

Analysis of data from routine City sampling at Outer Marina Beach from mid-1966 to December 1968 identified a significant variation between coliform levels for dry and wet weather conditions. The coliform levels increased by a factor of six from dry to wet weather conditions at a beach sampling station and by a factor of seven at sampling stations 250 to 1,500 feet offshore. Tidal current stage was found to cause fluctuations in coliform levels with higher concentrations observed at ebb and low slack stages than at flood and high slack stages.

Fluctuation of coliform MPN levels at Outer Marina Beach after cessation of wet weather discharges was also evaluated for two stations. It was found that median coliform levels at both stations decreased from a high value attained during wet weather to the background dry weather level within five dry weather days.

This analysis provides a basis for estimating the number of days of contamination per year attributable to combined overflows. It is estimated that the actual number of days that shoreline waters exceed bathing water standards due to wet weather overflows averages approximately 171 days per year.

Floatables

Variation in the density and distribution of floatable materials, both on the water surface and on the beaches, can also be related to wet weather bypassing of wastewater. Distribution is also related to surface drift which for the Central Bay leads to an accumulation on the ocean beaches outside the Golden Gate. Figure IV-2 summarizes data on observations of floatable material on ocean beaches from June 1967 through June 1968. The data indicate a significant increase in observable floatable material on ocean beaches during the rainy season from November through April in all areas. Floatable material was observed throughout the year near the Richmond-Sunset outfall.

The average floatable particulate concentration observed in the 1969-1970 wet weather surveys was 10.5 mg/m2 as compared to 1.5 mg/m2 observed during dry weather. A similar increase in dry weather levels over those for wet weather was also observed in the surface waters of Outer Marina Beach. Wet weather levels were consistently an order of magnitude greater for these sampling stations. There was also a difference between concentrations west of Marina Beach and those in the easterly sector. This corresponds to the lack of both combined and sanitary sewers west of Bakers Beach within the Bay.

Conservative Pollutants

An evaluation of the dispersion capability of the San Francisco Bay is available from a modeling study recently completed by the Department of Water Resources. In this study, a computer modeling technique was used to estimate the concentration of conservative pollutants under varying conditions of Delta outflow, tidal exchange, and pollutant discharge. The dispersion capability is defined in terms of equilibrium pollutant concentrations under steady-state conditions and non-stratified flow conditions.

For dry weather conditions, a tidal exchange ratio of 0.24 which is the average value for the Bay, a net Delta outflow of 1,800 cfs, and a discharge pattern approximating present conditions, the distribution of conservative pollutants presented in Figure IV-3 was obtained.

In the Department of Water Resources study, a comparison of pollutant concentrations is made for a tidal exchange ratio of 0.20, 0.24, and 0.30, Delta outflows of 1,800 and 5,000 cfs, and two patterns of discharge of pollutants. Discharge pattern A represents present-day conditions and pattern B represents implementation of a future water quality control plan proposed by the San Francisco Bay Regional Water Quality Control Board. Modeling results indicate that only the pattern of discharge of pollutants has a significant impact on concentration distributions, particularly in the South Bay.

The study was performed primarily to estimate dispersion capability of the Bay and a method was developed for approximating an increase in pollutant concentration at selected points in the Bay due to pollutant loadings at other points. This method allows determination of concentration profiles for toxicity but can be applied to discharges of any pollutant that does not change its characteristics with time. It would be possible to produce and compare concentration profiles of conservative pollutants for alternate discharge patterns in the Master Plan.

Turbidity

The data in Table IV-2 indicate a definite variation in level of turbidity under wet and dry weather conditions for the surface waters of the Bay and the Gulf of the Farallones. Higher values evidenced in the winter are attributable to the turbid fresh water outflows from the Delta. Being much less dense than the saline water of the Bay, the Delta outflow forms a thin surface layer of 10 to 15 feet while passing through the Bay. Under most wet weather conditions, a surface field formed by stormwater discharge by the City of San Francisco would not be discernible. Further upstream controls on fresh water inflow to the Bay could reduce background turbidity levels in the future. It is also possible for wet weather overflows to occur early in the rainy season before development of stratified conditions and high receiving water turbidity. At this time, storm overflow discharged as a surface field would be more turbid than the receiving water and would be easily visible within the Bay or nearshore zone of the Gulf of the Farallones.

OCEANOGRAPHIC DESIGN CRITERIA

Based on the above physical and chemical characteristics of the Gulf of the Farallones and the Bay, the following criteria which are considered important for the minimization of adverse impacts on receiving waters were developed.

For dry weather discharges, the fall season represents the design condition because:

- Water clarity is greatest.
- Surface net advection is lowest.
- Density stratification is least pronounced because of low fresh water inflow, and the tendency of an effluent field to rise to the surface is greatest.
- Atmospheric and water temperatures are at the annual high, and recreational use of the shore areas is likely to be the greatest.

For wet weather discharges the winter season represents the design condition for the obvious reasons. During the winter period of high fresh water runoff:

- Water clarity is lowest.
- Surface net advection is highest.
- Density stratification is most pronounced.

Oceanographic criteria which apply only to the Gulf of the Farallones may be summarized as follows:

- To achieve a continuously submerged effluent field, an outfall diffuser must be located outside the bar in 80 feet or more of water.
- A surface field released at any point inside the bar in a water depth greater than about 60 feet will be advected seaward.
- The bar area itself is too shallow to permit either surface installation of a major pipeline or good initial dilution for a major effluent discharge.
- Effluent discharged through a properly designed diffuser located west of the mouth of the Golden Gate will have no measurable effect on the Bay.
- Floatable material released west of the mouth of the Golden Gate will not enter the Bay.
- Any dry weather discharge to the Gulf of the Farallones should be located at least one mile offshore to:
    - Avoid the nearshore currents which have a net bayward displacement;
    - place a surfacing field beyond the limit of of easy visibility from shore; and
    - increase the minimum shoreward travel time.

A wet weather discharge might suitably be made less than one mile offshore near the mouth of the Golden Gate in an area where the effluent field would be entrained in the westward moving surface water mass.

An outfall and diffuser in the high current and unstable bottom area near the mouth of the Golden Gate will cost more per unit of length than in areas of lower currents.

The dissolved oxygen resources of the surface waters of the Gulf of the Farallones are greater outside the bar than inside the bar.

A surface effluent field in the Gulf of the Farallones will disperse horizontally in accordance with the formula:

$K = 20L^{4/3}$ sq. ft/hr, and vertically
$K = 10$ sq. ft/hr.

Oceanographic criteria which apply only to the Central Bay may be summarized as follows:

- Net advection of the surface layer in the Central Bay is seaward at all times of the year. Seaward advection is weakest in the summer and fall and strongest during periods of high runoff.
- Surface advection in the Bay south of the Golden Gate Bridge is much weaker than in the Central Bay, but still has a net seaward vector at most times and stations.
- Surface drift of floatables released in the mid-Central Bay is seaward at all seasons. No significant deposition will occur along the Bay shoreline, and the distribution along the ocean shoreline will be approximately the same as for an ocean release.
- Density stratification is sufficient to keep an effluent field submerged most of the time at initial dilutions of 100 to 1 or greater. At times in summer and fall, however, there is no density gradient, and the effluent field will surface.
- A surface effluent field in the Central Bay will disperse horizontally in accordance with the formula:

  $K = 33L^{4/3}$ sq. ft/hr, and vertically
  $K = 20$ sq. ft/hr.
- Dissolved oxygen resources of the Central Bay are in excess of the lower limiting values established by the Regional Water Quality Control Board and recommended by Bay-Delta Program.
- Tidal exchange at the Golden Gate brings 20 to 30 x 10^9 cubic feet of new ocean water into the Central Bay each 25-hour tidal cycle during the dry weather months, and up to twice that amount in wet weather.
- Tidal exchange at Alcatraz Channel brings 15 to 25 x 10^9 cubic feet of new water past that site each 25-hour tidal cycle in dry weather months.

ECOLOGICAL DATA

Diversity, distribution, and numbers of marine biota found in the San Francisco Bay, the Gulf of the Farallones, and adjacent ocean, and the effect of waste discharges on these biota, was obtained from studies by consultants and other researchers.

In 1969-1970, under contract with the City of San Francisco, Brown & Caldwell performed an ecological investigation of the Bay and the Gulf of the Farallones to assess the impact of proposed waste discharges. This study concluded that:

- No significant toxic response to seven species of fish could be demonstrated after 96 hours exposure in dilutions of San Francisco sewage effluent greater than 1:100.
- Eggs and larvae of Dungeness crabs which showed a toxic effect at a dilution of 1:50 and a stimulatory response at greater dilutions.
- There was no toxic effect from the effluent in dilutions equal to or greater than 1:50 on three-spined stickleback or first-stage Dungeness crab zoea.

Three sampling programs were conducted by Engineering-Science, Inc., in 1969-70 at the Outer Marina Beach to identify the water quality and biological characteristics of surface water, the benthos, and the beach intertidal zone. The following conclusion regarding biota in the area was derived from the study:

> "Both the concentrations of microplankton in the receiving waters and benthic animals in the sediments were low and represented by a number of varieties. The combination of low and diverse populations is considered generally to be representative of a balanced ecology."

ECOLOGICAL DESIGN CRITERIA

Based on the above studies and results reported by other researchers of the marine biology of the Gulf of the Farallones and the Bay, design criteria were developed to be used as a guide for selection of the levels of waste treatment and discharge location necessary to provide maximum protection to the marine resources. It was assumed that future toxicity loadings would be equivalent to chlorinated primary effluent. In addition, a factor of safety of 10 was incorporated.

Design criteria include:

- Where possible, effluent dilutions along the shoreline or in shallow water should not be less than 1000 to 1 for more than 24 hours at a time.
- Gravid Dungeness crabs appear to be vulnerable to the effects of exposure to sewage effluent through reduced egg-mass viability. The benthos in areas where gravid crabs are present should not receive sustained exposure to effluent in dilutions less than 500 to 1.
- Plankton and fish populations should not be exposed to effluent dilutions less than 100 to 1 for more than 24 hours or less than 200 to 1 for long-term exposure.
- Deposition of sewage solids on the ocean floor should be avoided. Settled material of sewage origin has been demonstrated to have a negative effect on benthic populations.
- From the standpoint of protecting the marine ecosystem in the Gulf of the Farallones, a surface effluent field is preferable to a submerged field for two reasons:
    - A surface field will be transported away from intertidal areas.
    - A surface field provides the greatest factor of safety for protection of the benthos.

  This is particularly true during the winter season when gravid crabs are migrating shoreward.
- As a general rule, dry weather discharges should be limited to about 100 mgd per outfall. Evidence from Southern California outfalls shows that larger discharges have had a measurable adverse effect on the marine environment.
- Since rocky intertidal areas have a greater diversity and productivity than sandy beaches, a preferred location for an outfall in the Gulf of the Farallones would lie south of a line extended westward along the centerline of the Golden Gate. The sandy beaches to the south are not productive clamming areas and are not likely to be protected for the taking of shellfish.
- Submarine pipelines and diffusers in the Gulf of the Farallones should be constructed in a manner which will not impede the periodic shoreward migration of breeding Dungeness crabs and certain other benthos.

DATA EVALUATION

The data summarized above describing the receiving water conditions and marine biology of the San Francisco Bay and the Gulf of the Farallones were used in the Development of the Master Plan to select the type and placement of the outfalls and the necessary treatment level. The assimilative capacity of each proposed or existing outfall location was estimated and the treatment level determined to ensure compliance with requirements of the Regional Water Quality Control Board for both wet and dry weather conditions.

In developing the Master Plan certain assumptions must be made of the level of water quality protection that will be required in the future for the Bay and the ocean. It is correctly stated in the Master Plan that a higher level of effluent quality will be required for discharge to the Bay than to the ocean; however, the level has not yet been defined for the Bay and questions still remain on ocean discharge requirements.

There are sufficient data to develop general conclusions regarding the impact of discharge at various locations. Criteria have been developed to determine the relative benefits of alternative discharge sites. Based on these design criteria, it has been possible to analyze the impact of alternate waste treatment and disposal schemes in sufficient detail to properly conclude that the ocean disposal alternative is far superior with regard to environmental protection.

Data on the receiving water conditions of the Bay have been gathered over a long period of time and consists of research results from studies by State agencies, private consultants, and independent researchers. The data are generally more complete and descriptive of actual conditions than are found in other areas where discharge occurs or is proposed.

Investigation and documentation of conditions existing in the Gulf of the Farallones is much less thorough and the majority of these data were obtained in a one-year study. As a result, there are limited data on physical characteristics of the Gulf and the conclusions derived from this study may not accurately represent the extremely variable conditions which exist in this very complex system.

A similar situation exists with respect to the determination of toxic effects of wastewater on the marine biota in the receiving waters. Additional data are presently being acquired to either substantiate or alter present conclusions regarding the toxicity of the waste to the crab population.

A more detailed description of currents, mass water movement, and surface drift associated with the proposed discharge location would facilitate a better understanding of that particular area. These data could be used to further identify the ability to maintain a submerged or surface effluent field. Additional oceanographic data would also permit a closer approximation of movement of the effluent field. Extent of possible beach contamination, exposure of the benthos to critical concentrations, and movement of floatable materials could also be more clearly defined. Identification of dilution and dispersion would permit determination of the concentrations of potential pollutants in receiving waters to allow correlation with toxicity studies.

The City of San Francisco recognizes the need for certain additional supplemental data regarding receiving water characteristics and the impacts of waste discharge on marine resources. In this regard, studies are underway to evaluate the impacts associated with marine waste disposal especially its toxicity to marine resources.

Outfall Location	Pe Fl Ra (m
Existing North Point Outfall Under Piers 33 and 35 800 Feet Offshore	1
Existing Richmond-Sunset Outfall — Mile Rock Outfall	
Existing Southeast Outfall 500 Feet Offshore	7
Alcatraz Channel-South of Alcatraz Island about 5000 Feet Offshore	2
West of Pier 37 2500 Feet Offshore	15
Gulf of Farallones Inside Bar One Mile Offshore	7
Gulf of Farallones Inside Bar Slightly Less than One Mile Offshore	34
Gulf of Farallones One Mile Offshore Off Lands End Inside Bar	14
Gulf of Farallones Off Lands End Inside Bar	2
Gulf of Farallones Off Lands End Inside Bar	6
Gulf of Farallones Off Lands End Inside Bar	1
West of Lake Merced One Mile Offshore	7
West of Lake Merced One and One-Half Miles Offshore	52
West of Lake Merced Over Three Miles Offshore	34

TABLE IV-1
DESCRIPTION OF EXISTING & PROPOSED OUTFALLS

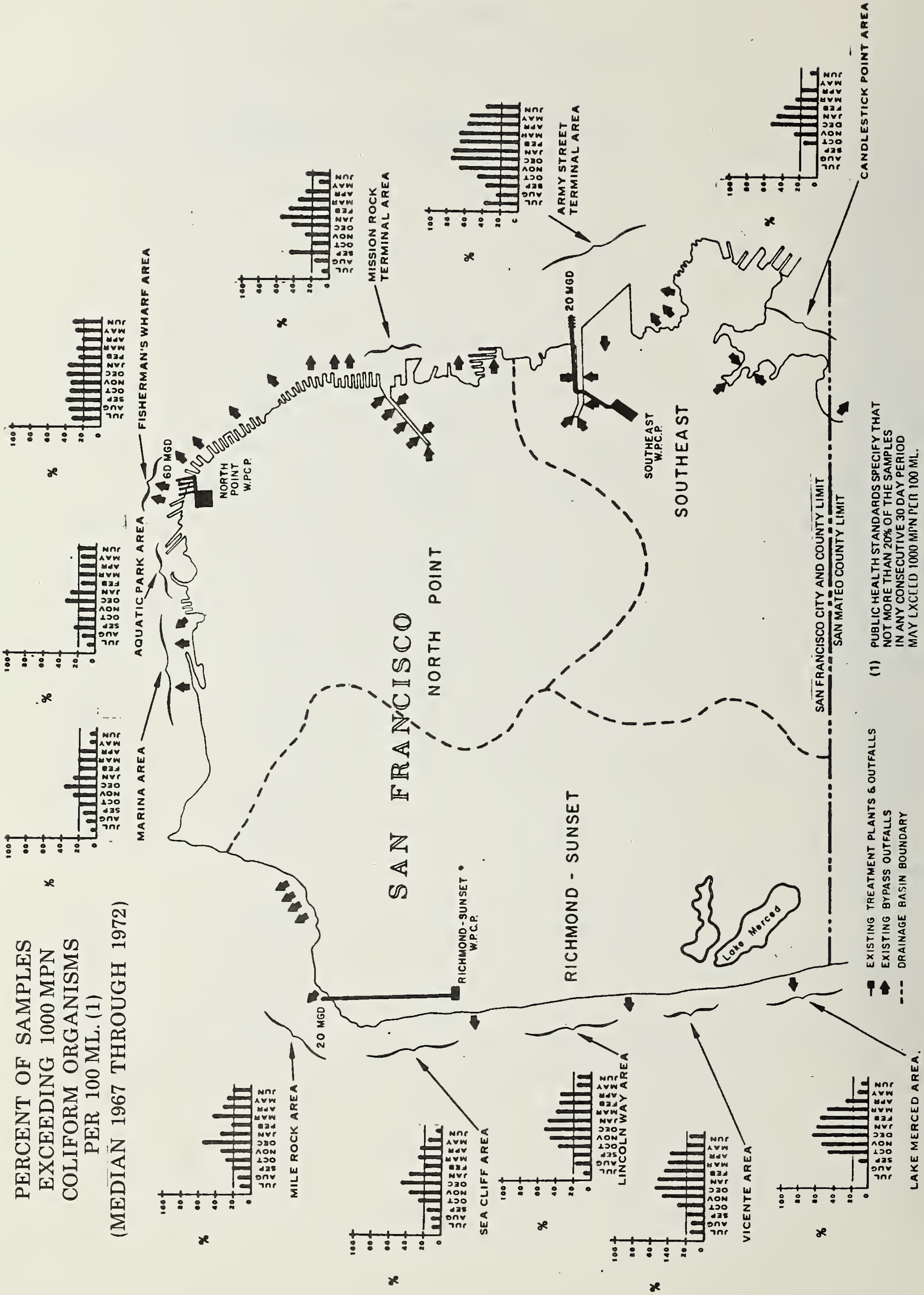
Outfall Location	Peak Flow Rate (mgd)	Type of Discharge - Outfall Type	Water Depth at Mean LLW (ft)		Current Velocity		Type of Field Produced		Minimum Dilution			General Movement of Effluent Field		Net Movement of Effluent Field
			At Outfall	Range in Adjacent Water	Surface	Bottom	Winter	Fall & Summer	In Stabilized Field	On Bottom	Upon Reaching Shoreline	Ebb Tide	Flood Tide	
Existing North Point Outfall Under Piers 33 and 35 800 Feet Offshore	160	Dry Weather — Point Release	10'				Surface	Surface	3 to 4:1			West Toward Golden Gate Along Shoreline	South Along Shore- Toward Bay Bridge	Seaward through Golden Gate in Contact w/Shoreline
Existing Richmond-Sunset Outfall — Mile Rock Outfall			1.3'				Surface	Surface						
Existing Southeast Outfall 500 Feet Offshore	70	Dry Weather — Horizontal Jet Diffuser	40'		Up to 1.5 K	Up to 1.5 K	Submerged	Submerged w/ Periodic Surfacing	53:1			Along Shoreline North Toward Fisherman's Wharf	Along Shoreline South Past Hunters Point into South Bay	Bayward around Hunters Point and into South Bay
Alcatraz Channel-South of Alcatraz Island about 5000 Feet Offshore	200	Dry Weather — Horizontal Jet Diffuser	70'	40'-100'	1-4 K	1-2 K	Submerged	Submerged w/ Periodic Surfacing	140:1	2000:1	1000:1	West Toward Gate No Contact w/ Shoreline	Bayward with Possible Shore-line Contact	Bayward
West of Pier 37 2500 Feet Offshore	150	Wet Weather — Vertical Jet Diffuser	55'	40'-100'			Surface	Surface	10:1			Seaward Through the Gate — No Contact with Shoreline	Bayward South Toward Bay Bridge	Strongly Seaward
Gulf of Farallones Inside Bar One Mile Offshore	70	Dry Weather — Horizontal Jet Diffuser	60'	30'-80'	1-1.5 K		Submerged	Surface	110:1	900:1	1400:1	Strongly Seaward	Toward Golden Gate with Edge Intersecting Shoreline	Seaward
Gulf of Farallones Inside Bar Slightly Less than One Mile Offshore	340	Dry Weather — Horizontal Jet Diffuser	95'	70'-110'			Submerged	Generally Submerged	125 to 160:1	> 500:1	500 1000:1	Westward and Southward Toward Oceanic Currents	Toward Centerline of Golden Gate with Possible Shoreline Contact	Bayward
Gulf of Farallones One Mile Offshore Off Lands End Inside Bar	140	Dry Weather — Horizontal Jet Diffuser	75'	50'-90'	1.3 K		Submerged	Surface	130:1	> 500:1	> 1000:1	Westward and Southward Toward Oceanic Currents	Toward Centerline of Golden Gate with Possible Shoreline Contact	Bayward when Submerged, Seaward when Surface Field
Gulf of Farallones Off Lands End Inside Bar	255	Wet Weather — Vertical Jet Diffuser	100'	70'-110'			Surface	Surface	10:1			Strongly Seaward	Generally Seaward	Seaward
Gulf of Farallones Off Lands End Inside Bar	620	Wet Weather — Vertical Jet Diffuser		50'-90'			Surface	Surface	10:1			Strongly Seaward	Generally Seaward	Seaward
Gulf of Farallones Off Lands End Inside Bar	100	Wet Weather — Vertical Jet Diffuser					Surface	Surface				Strongly Seaward	Generally Seaward	Seaward
West of Lake Merced One Mile Offshore	70	Dry Weather — Horizontal Jet Diffuser	50'-60'	30'-80'			Submerged	Generally Submerged						
West of Lake Merced One and One-Half Miles Offshore	520	Wet Weather — Vertical Jet Diffuser	50'	30'-80'			Surface	Surface	16:1	500 or 1000:1		Southerly Surface Advection Parallel to Shore		
West of Lake Merced Over Three Miles Offshore	340	Dry Weather — Horizontal Jet Diffuser	80'	60'-90'			Submerged	Generally Submerged	107:1	1000:1	1000:1			

TABLE IV-2
RECEIVING WATER CONDITIONS

	Gulf of Farallones (1) Inside Bar	Gulf of Farallones (1) Outside Bar	Central Bay Alcatraz (2)	Lower Bay(2) Near Hunters Pt.
DO Concentration mg/1				
Dry Weather				
Surface	6.5-8.5	8-10		
Bottom	6.5-8.0	4-6		
Wet Weather				
Surface	8-9	8-9		
Bottom	8-9	8-9		
Minimum			6.5	7.0
Mean			7.3	7.4
Maximum			8.2	8.5
Secchi Disk Transparency (feet)				
Dry Weather	5-17	6.5-25		
Wet Weather	1.5-8	4-15		
Jan-June Mean			3.5	2.5
July-Dec Mean			6.5	6.0
Suspended Solids mg/1				
Minimum			5	8
Mean			15	29
Maximum			38	56
Temperature °C				
Minimum			10.1	10.7
Mean			13.5	14.8
Maximum			19.0	21.0
Nitrate Nitrogen mg/1				
Minimum			0.05	0.06
Mean			0.15	0.12
Maximum			0.48	0.21
Reactive Phosphate mg/1				
Minimum			0.2	0.3
Mean			0.3	0.5
Maximum			0.4	0.8
Ammonia Nitrogen mg/1				
Minimum			0.16	0.08
Mean			0.24	0.34
Maximum			0.36	0.55

(1) Ref. 24
(2) Ref. 33

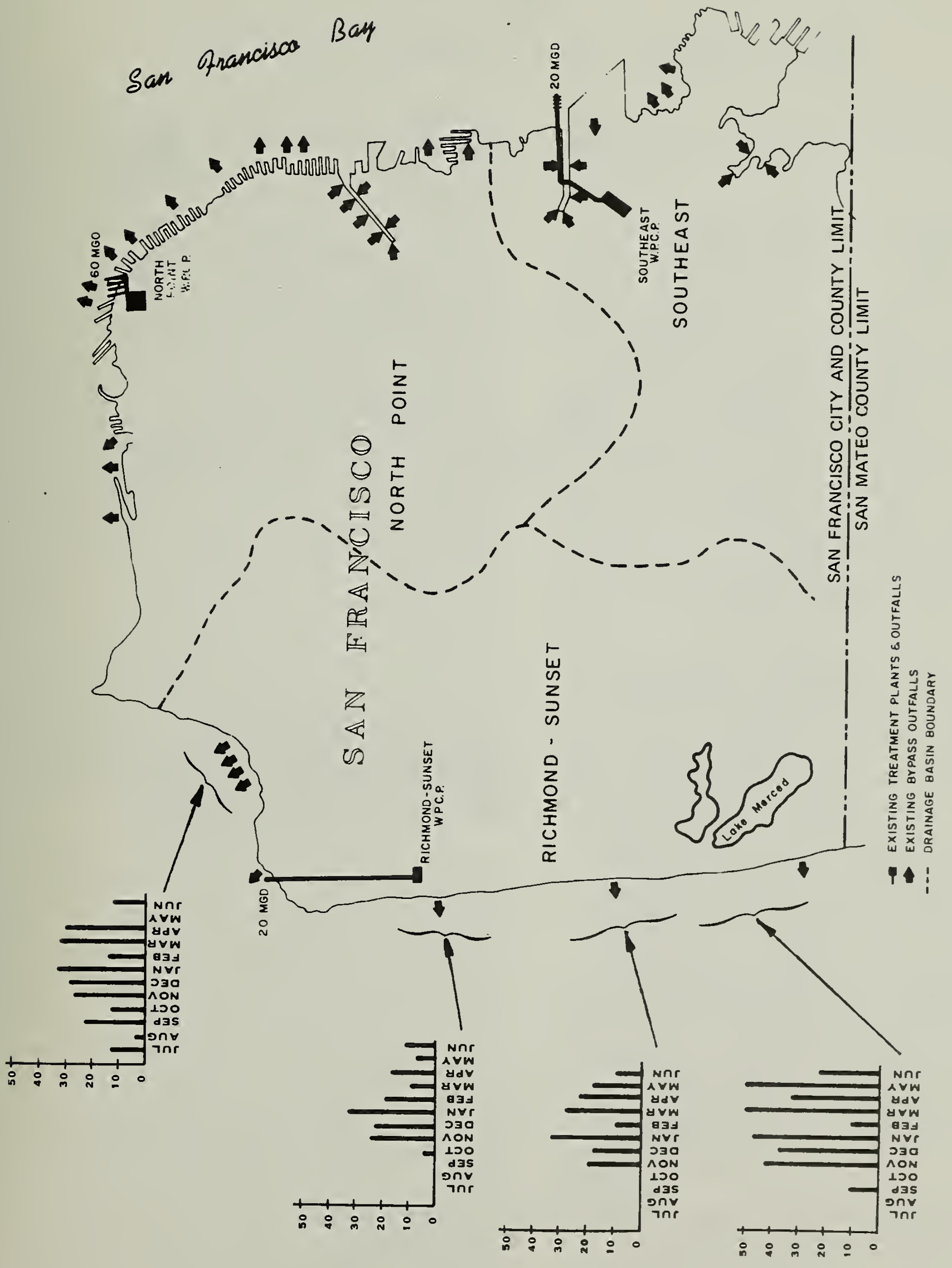
FIGURE IV-1



PERCENT OF SAMPLES EXCEEDING 1000 MPN COLIFORM ORGANISMS PER 100 ML. (1) (MEDIAN 1967 THROUGH 1972)

(1) PUBLIC HEALTH STANDARDS SPECIFY THAT NOT MORE THAN 20% OF THE SAMPLES IN ANY CONSECUTIVE 30 DAY PERIOD MAY EXCEED 1000 MPN PER 100 ML.

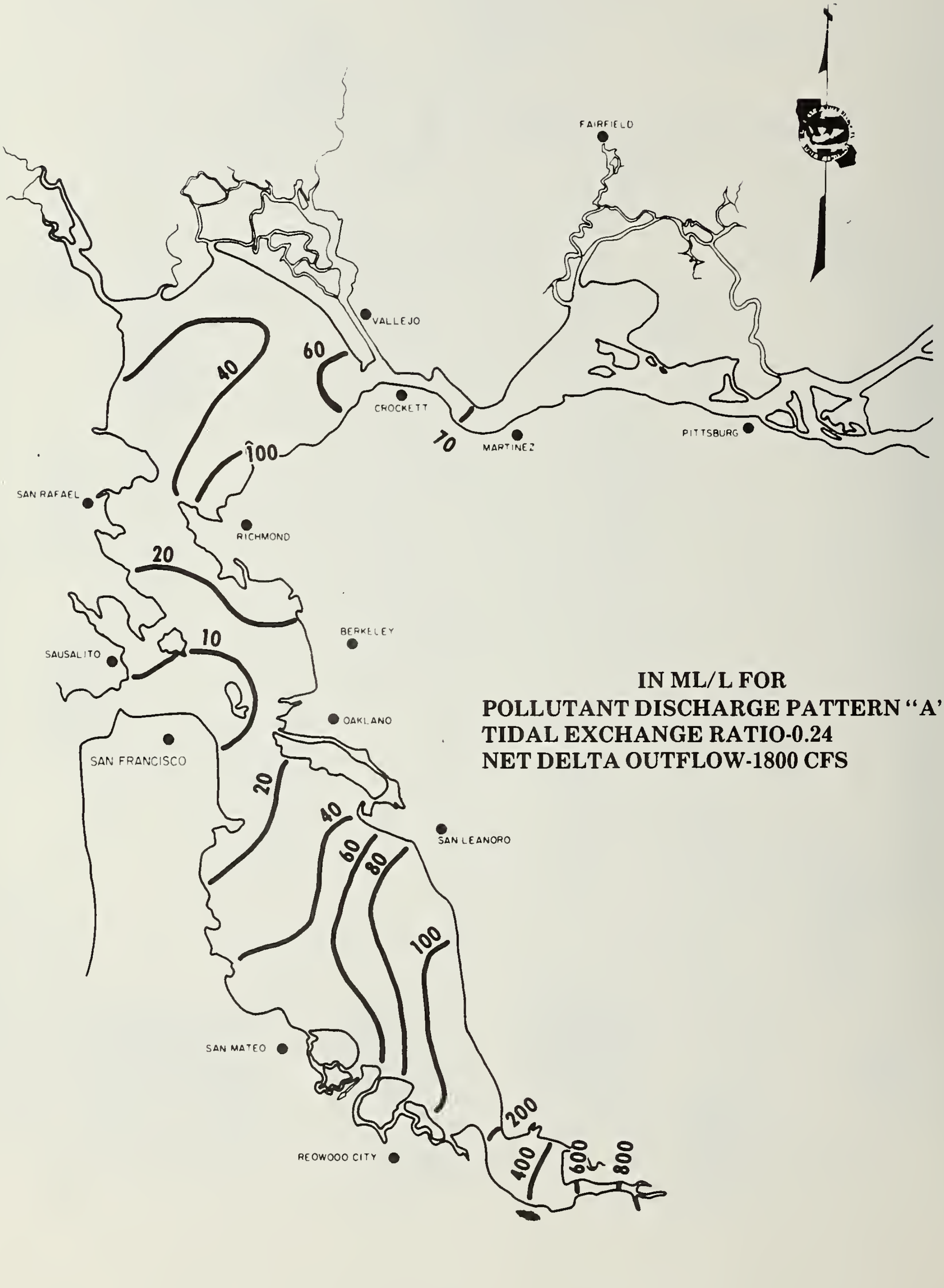
FIGURE IV-2



PERCENT POSITIVE OBSERVATIONS OF FLOATABLE MATERIAL ON OCEAN BEACHES (1967-1968)

FIGURE IV-3

POLLUTANT CONCENTRATIONS



IN ML/L FOR
POLLUTANT DISCHARGE PATTERN "A"
TIDAL EXCHANGE RATIO-0.24
NET DELTA OUTFLOW-1800 CFS

Chapter V

REGULATIONS OF GOVERNMENTAL AGENCIES

The Master Plan is primarily influenced by the plans and policies of the Federal Environmental Protection Agency, the State Water Resources Control Board, and the California Regional Water Quality Control Board, San Francisco Bay Region.

The Master Plan is affected by other laws and programs including the National Environmental Policy Act, the State Environmental Quality Act, the State and Regional Coastline Protection Commissions, the Bay Conservation and Development Commission, the Bay Area Sewage Services Agency, the Association of Bay Area Governments, the State Department of Fish and Game, the Federal Bureau of Sport Fisheries and Wildlife of the Department of Interior, the U.S. Army Corps of Engineers, the State Lands Commission, the Bay Area Air Pollution Control District, the State Department of Public Health, and such local requirements and policies as are established by branches of City government including planning, parks, and recreation, health, and fiscal.

The California Regional Water Quality Control Board, San Francisco Bay Region, through public pronouncements in the late 1950's and continuing through the 1960's clearly expressed its concern that San Francisco control the overflows of untreated combined storm and sanitary sewage.

The Regional Board first formally expressed this concern in 1967 with the adoption of an order requiring the City to submit a program to eliminate the discharge of sewage not meeting bacteriological standards for saltwater bathing in the shoreline areas on the northwest and west portions of the City. In January 1970 orders were adopted requiring the City to comply with specific effluent quality and receiving water requirements for the bypass of combined waste from the entire City. This action, together with new separate waste discharge requirements for dry weather flow from waste treatment plants, resulted in development by the City of the Master Plan for Waste Water Management to control wet and dry season waste discharges.

On October 18, 1972, Public Law 92-500 which provides for a uniform national approach to water pollution became law. The national program can be administered by individual states, where states have compatible programs. The California Legislature adopted AB 740 which substantially altered California law to comply with the new Federal program.

This chapter relates the Master Plan to the total complex of present and projected governmental regulations.

WATER QUALITY

In the past, California's requirements as established by the Regional Water Quality Control Board have emphasized receiving water quality conditions. Effluent requirements have been added in recent years. New Federal regulations will specify some form of secondary treatment for dry weather, and possibly wet weather, flows. Regardless of specific requirements of State and Federal future regulations, the new law provides for demonstration of the cost-effectiveness of any proposed treatment system.

Waste Discharge Requirements

The Regional Board has adopted separate requirements for the discharge of waste from the treatment plants and from the system during wet weather periods. The controlling provisions of these requirements are summarized:

Disinfection — The requirements in effect provide that receiving water conditions meet bacteriological standards for water-contact sports throughout the Bay and in the shoreline area of the ocean at all times. The Richmond-Sunset requirements specifically prohibit the discharge of undisinfected waste within 50 feet of shore. These requirements can be met only by disinfection of all waste before discharge or by discharging the waste into the ocean at a sufficient distance and depth from shore to assure that high coliform concentrations do not result in the nearshore areas.

Wet Weather Effluent Requirements — The wet weather requirements for North Point and Southeast diversion structures include a minimum effluent toxicity provision of 75 percent minimum survival of test organisms in undiluted waste. 25 mg/1 grease and 1.0 ml/1 of settleable matter is included as a "goal." Consistent compliance with these requirements for wet weather discharges in these locations cannot be met without secondary treatment due to the highly variable nature of the combined waste, the conditions and methods of bypassing at San Francisco, and the strong waste characteristics during initial flushing of the sewer system.

Dry Weather Effluent Requirements — The only presently applicable effluent quality requirement for the three waste treatment plant discharges is a maximum allowable concentration of settleable solids of 1.0 ml/l/hour. The requirements for Richmond-Sunset contain an additional limitation of 0.5 ml/l/hour as a 24-hour average. Additional effluent requirements become applicable for BOD and coliform concentrations for the Southeast and North Point discharges when receiving waters violate objectives.

Although the settleable solids limitation easily can be met with primary treatment, the 90 percent removal of BOD requirement could only be met by secondary treatment. The coliform restriction requires disinfection of effluent.

Receiving Water Requirement Applicable to Treatment Plant Discharges—In all cases receiving water requirements are not only restrictive, but consistent compliance could be achieved only by secondary treatment. At Southeast secondary treatment may not be adequate to assure compliance even with existing waste discharge requirements — particularly if flow quantity is significantly increased.

Time Schedules in Waste Discharge Requirements — None of the requirements contain a time schedule for compliance. A program to achieve compliance by the wet and dry weather discharges from the Richmond-Sunset area was required to be submitted in June 1967. No program for compliance by the North Point dry weather discharge was required. A plan was required prior to November 30, 1969, for compliance with Southeast dry weather requirements and with other "ranges" representative of secondary treatment. For the North Point and Southeast wet weather discharges, the requirements specify that "the discharger submit a time schedule for all studies necessary to determine the feasibility of compliance."

Cease and Desist Orders

Cease and Desist Order 72-90 regarding the North Point sewage treatment plant was adopted October 26, 1972, by the Regional Board. The order required that by December 1, 1972, the City submit a conceptual plan and time schedule for compliance with all requirements. A schedule was established for certain interim improvements.

The Regional Board also adopted Cease and Desist Order 72-91 regarding the Southeast sewage treatment plant on October 26, 1972. The order contains similar provisions as in Order 72-90.

On January 11, 1973, the Regional Board adopted Cease and Desist Orders which amended Order 72-90 and Order 72-91. These orders set forth a time schedule for an immediate improvement program requiring dechlorination facilities at North Point and flocculation testing.

The Cease and Desist Orders adopted January 11, 1973, set forth the date of June 1, 1977, for compliance with all requirements. Compliance with these orders can be assured only by construction of secondary treatment facilities for the North Point and Southeast service areas by June 1, 1977. The orders include a separate dry weather program to achieve compliance.

Basin Plans

An Interim Water Quality Control Plan for San Francisco Bay Basin has been approved by the State and the Environmental Protection Agency. The Plan contains general provisions that are applicable to the short-term aspects of the San Francisco problem as follows:

- That wastes be discharged sufficiently far from shore and disinfected to assure maintenance of bacteriological standards acceptable for swimming.
- That the continual discharge of primary treated effluent into San Francisco Bay is not acceptable.

The Regional Board staff recently proposed that the Interim Basin Plan be amended to include specific receiving water requirements for toxicity in South San Francisco Bay area and a delineation of areas of special biological significance in the ocean area off the coast of San Francisco. These proposed changes, for which hearings have been conducted but action not taken, could influence significantly the scope of the Master Plan and could affect the available alternatives. The restrictive toxicity requirement for discharges to the Bay could result in the necessity for treatment in excess of secondary for discharges at the present Southeast plant site.

The areas of special biological significance could restrict the areas where the ocean outfall can be located since the natural water quality conditions that must be maintained within these specified areas effectively prohibit all waste discharges.

The State and Regional Boards are developing a "final" or "fully developed" basin plan for the area. This plan is presently scheduled for completion by the spring of 1974 and publication in June or July of 1974. The final plan most likely will reflect the latest changes in State and Federal regulations, provisions of the State's Ocean Plan, recently proposed water quality objectives for San Francisco Bay, and high priority for construction of facilities to achieve secondary treatment for dry weather flows.

The trend has been and most likely will continue to require higher levels of treatment to comply with water quality criteria for parameters such as toxicity, bacteriological quality, and aesthetics. Although not shown necessary at this time, a limitation on biostimulatory substances may be included. These changes may result in the requirement for advanced or tertiary waste treatment for continual discharge to the Bay.

The priority assigned to control of wet weather flows is a most important feature of the plan and will affect long-range financial support for the Master Plan.

State Policy

On July 6, 1972, the State Water Resources Control Board adopted a policy statement setting forth certain general principles for management of wastewater including:

- Reclamation and reuse to be considered in planning.
- Regional consolidation of wastewater management systems.
- Source control of environmentally hazardous substances.

The Master Plan, together with implementation of the industrial waste control program, is compatible with the provisions of this State policy.

The potential for reclamation and reuse of water near San Francisco is very limited — particularly for the large volumes of waste generated during winter months. A future reuse system would require transportation to the Central Valley of California for augmenting fresh water outflows by discharge of reclaimed water into the western Delta or for irrigation. These possiblities are now being studied by the Department of Water Resources.

The location of a treatment plant at Lake Merced followed by disposal of the wastewater to the ocean does not reduce reclamation potential since the cost of transporting water across the City is very minor compared to the cost of transporting the water to areas of likely future reuse.

Adequate environmental protection is necessary before a reuse program is implemented and for seasonal discharge thereafter. At a given level of treatment this is best assured by ocean disposal of wastes.

Ocean Plan

In July 1972 the State Water Resources Control Board adopted a comprehensive plan governing all waste discharges to the ocean. The Plan will affect the design, construction, and operation of all waste treatment plants and outfall systems that discharge into the ocean and is therefore of major concern to the design of the proposed treatment plant and outfall system in the Lake Merced area. The provisions of the Plan can be summarized as follows:

- A minimum of secondary treatment of some type (either chemical, physical or biological) is required for all municipal and industrial wastes prior to discharge to the ocean.
- Stormwaters are not exempt from the quality provisions of the Plan. However, secondary treatment of stormwaters is not required and it is likely that compliance can be achieved with a lesser degree of treatment during storm periods.
- The Ocean Plan does not contain a specific schedule for compliance.
- Receiving water conditions on the ocean beaches must be maintained acceptable for body-contact sports throughout the year for a minimum distance of 1,000 feet from the shoreline.

The Ocean Plan has the following general meaning with regard to San Francisco:

- Bypassing of wastes as presently practiced will violate provisions of the Plan.
- The present method of discharging wastes from the Richmond-Sunset treatment plant is unacceptable due to the location of the discharge point in an area near the shoreline.
- Compliance with the Plan will require solutions to both the wet weather and dry weather problems.

Federal and Related State Law Changes

Until recent legislation, the primary function of the Environmental Protection Agency and its predecessor was to provide financial assistance for construction of waste treatment facilities, support and technical advice to State programs, approval of State formulated standards, and enforcement through a cumbersome conference procedure. This has all changed with enactment of Public Law 92-500.

Public Law 92-500 provides uniformity in establishing national water quality standards for effluent quality, receiving water standards, treatment levels, and industrial pre-treatment facilities. A national permit system is established, and the grant program is expanded to assist in implementing Federal goals.

EPA can delegate substantial portions of the program to the individual states, and indications are that California will receive formal delegation. Thus the relationship between the Regional Board and the City will continue but be modified in that the Regional Board will be implementing federally adopted regulations.

An important responsibility of EPA under both the old and new laws is the water quality standard setting process in which the states establish and submit water quality standards to EPA for approval. The Federal Government has had the authority since 1965 to initiate enforcement actions in the case of standards violation. Although receiving water standards have been consistently violated by San Francisco's bypass of untreated waste during winter, the Federal Government has not initiated enforcement proceedings.

The new Federal Act provides that by July 1977 all waste from municipal treatment works receive at least secondary treatment and any additional treatment necessary to meet water quality standards regardless of whether or not built with aid of Federal funds. While this provision is applicable to all municipal discharges, the definition of "treatment works" includes a separately defined section on "combined sewer facilities" making them subject to cost effective analysis to determine grant eligibility. This implies that a different level of treatment will be acceptable for combined flows. The cost effective analysis guidelines are being developed by EPA and are to be published by May 18, 1973.

Additional requirements of Federal legislation include:

- All sewage treatment plants in operation on July 1, 1977 — whether or not built with the aid of a Federal grant, and no matter when built — must provide a minimum of secondary treatment. Exception: A plant being built with the aid of a Federal grant that was approved before June 30, 1974, must comply with the secondary-treatment requirement within four years but no later than June 30, 1978.
- Also by July 1, 1977, all sewage treatment plants must apply whatever additional more stringent effluent limitations that may be established by EPA or a State to meet water quality standards, treatment standards, or compliance schedules.
- All publicly-owned waste treatment plants — whether or not built with the aid of a Federal grant, and no matter when built — will have to use "best practicable" treatment by July 1, 1983. Regulations interpreting "secondary treatment" and "best practicable treatment" were not available at the time of this writing. These regulations are essential in defining the acceptability of the Master Plan.
- Industrial user charges must be repaid (at least 50%) to the United States or used by the City for local costs.

Until the recent Federal law, the basic law governing water pollution control in California was the Porter-Cologne Water Quality Control Act. Near the end of 1972, the Legislature passed AB 740 which amended the Porter-Cologne Act to provide compliance with national legislation.

The key section of AB 740 can be summarized as follows:

> The State Board and the Regional Boards are required to issue waste discharge requirements for persons discharging into navigable waters of the United States which ensure compliance with the applicable effluent limitations, water quality related effluent limitations, national standards of performance, toxic and pretreatment effluent standards, and any ocean discharge criteria required or authorized by the Federal Water Pollution Control Act.

While this section and future Federal regulations will restrict the ability of the Regional Boards to consider each discharge individually, it is likely that some individual consideration will continue. The factors affecting the wastewater management program of the City of San Francisco are unique. The combination of combined sewers, geographic location, rainfall pattern, and location of industry and residential areas collectively requires a unique solution.

Waste discharge requirements under the new laws will be called "permits" and a minimum level of secondary treatment will be required.

State Department of Public Health

The State Department of Public Health is concerned primarily with the maintenance of bacteriological conditions that will permit swimming and harvesting of edible shellfish in the waters of San Francisco Bay and coastal areas. While the Department can take independent action in the specific case of contamination, its authority is exercised primarily by supporting the activities of the water quality regulatory agencies such as the

California Regional Water Quality Control Board. It is conceivable that the Department could take action directly against the City for winter overflows.

State Department of Fish and Game

The State Department of Fish and Game has played a major role in influencing a decision of the State and Regional Boards regarding establishment of waste discharge requirements, the preparation of water quality control plans, and adoption of policies. While the Department has enforcement authority under Section 5650 of the Fish and Game Code, that authority relates to directly-caused fish kills and the factors associated with the Master Plan are more related to long-term environmental effects.

The Department's major concern recently has been to assure protection of the crab breeding grounds which have been reported to extend into the Gulf of the Farallones and approach the zone of the proposed Lake Merced outfall. Oceanographic work to date has not satisfied the Department that the crab fishery will be protected and additional work is underway.

U. S. Bureau of Sport Fisheries and Wildlife

The U. S. Bureau of Sport Fisheries and Wild life has shown great concern about the effects of waste discharge. The Bureau's role in Federal Government parallels that of the Department of Fish and Game — the Bureau serves as advisor to the Environmental Protection Agency and the Army Corps of Engineers in permit activities. The Bureau in recent years has considered that inadequate attention has been given to long-term protection of the marine environment and has generally opposed the extension of outfalls and expansion of volume of waste discharged to the marine environment. Review in many activities listed above is an important factor and the Bureau should be involved in the early planning stages of any project.

U. S. Geological Survey

The U. S. Geological Survey has provided information upon which to make judgements concerning water quality. Recent studies of USGS have provided information concerning nutrients and flow patterns in San Francisco Bay. Conclusions of these studies regarding the buildup of conservative constituents and lack of flushing capacity of the Bay would militate against Bay discharge and favor ocean disposal.

Bay Area Sewage Services Agency

The Bay Area Sewage Services Agency (BASSA) is an independent wastewater management agency responsible for preparation of a regional water quality management plan designed to meet the objectives adopted by State and Federal legislation. BASSA was formed prior to recent State and Federal law changes and its latitude in deciding on alternate plans will be substantially narrowed as a result of new Federal regulations.

BASSA represents all Bay area sewage agencies and can actually construct facilities if local agencies are not able to. BASSA's effect on the Master Plan will be limited since the Master Plan primarily affects San Francisco. In the long run, BASSA's concern with regional wastewater reclamation facilities could affect San Francisco although the City has the least potential for reclamation among the major sewage systems.

OTHER ENVIRONMENTAL REGULATIONS

Environmental Impact Review

The National Environmental Policy Act and the California Environmental Quality Act provide procedures for environment analysis of all public works projects. Those projects which are subject to considerable public concern or have a potential impact on the environment must be analyzed in an environmental impact report prepared by the approving agency. While AB 740 and recent State environmental impact report guidelines exempt water quality permits from the preparation of impact reports, the impact report is necessary to secure grants and for the City to comply with State law (AB 889-1972).

The City's first-phase dry weather program, including a North Point to Southeast pipeline and treatment improvements at the Southeast plant, has been delayed perhaps a year as a result of EPA's determination to prepare an environmental impact report. While this report will be based largely on information supplied by the City EPA is preparing an independent analysis.

The preparation of an impact report is not a regulatory or approval act, but it can point out concerns other than cost and compliance with water quality objectives that are of significance to City officials and the State and Federal agencies in approving the project. This requirement greatly increases the cost and time required in preliminary planning.

Air Quality Regulations

Treatment elements of the Master Plan will be affected by restrictions on emissions to the air. Incineration of wastewater sludge is a possibility, and lime treatment of waste (an alternative secondary process) normally includes incineration to recalcine lime. The Master Plan does not contain detailed information on air quality standards or an analysis of the acceptability of alternative incineration and scrubbing processes.

While the Bay Area Air Pollution Control District severely limits emissions from stationary sources to comply with long-range plans, the trade-offs of air quality, water quality, and land use must be considered together with the alternatives in making final decisions concerning air emission requirements. Due to the importance of this matter, it is recommended that discussions continue with representatives of State and Regional air quality agencies for the purpose of defining acceptable emission standards at the Southeast and Lake Merced sites so that accurate cost estimates can be made for alternative solids-handling processes.

Land Use Controls in Bay and Coastal Areas

There are five Federal and State agencies that have primary jurisdiction in the shoreline areas:

U. S. Army Corps of Engineers — A Corps permit is necessary to construct anything within navigable waters of the United States — which includes the San Francisco shoreline. To obtain such a permit, it is necessary that the City secure a certification from the State Water Resources Control Board. The certification, which is based on recommendations from the California Regional Water Quality Control Board, relates to the effects of the proposed facilities. In the past, this procedure has been used by various agencies as a vehicle to alter or stop proposed waste treatment and outfall projects. If all agencies — State, Federal, and local — are properly consulted in the environmental impact review procedure, then obtaining this permit will not significantly affect implementation of the Master Plan.

The Army Corps of Engineers is studying the possibility of disposing of municipal waste on land in large open areas within the Bay area complex or by transporting to areas within the Central Valley for land disposal. The vast acreages involved in land disposal programs, the unknown effects of the accumulation of toxic substances in the soil mantle, and the economics of these alternatives are questions that will be answered in the course of the study program. This is a long-range program and not likely to have an effect on initial stages of the Master Plan.

Bay Conservation and Development Commission — A permit from BCDC is necessary to extend facilities across the shoreline. Historically, the relationship between BCDC and the Regional Water Quality Control Board has been that BCDC would accept the Board's determination regarding water quality and BCDC would determine the acceptability of structural aspects.

Coastal Zone Commissions — In 1972 the voters of California approved the establishment of a series of Coastal Commissions. The North Central Coastal Commission is required to approve construction of structures within the coastal zone which extends inland 1,000 yards from the mean high tide line. Therefore, the approval of the Coastal Commission will be needed for the proposed ocean outfall and for the treatment plant if located within its zone of control. It can be presumed that the Commission's review will be related to the land use, aesthetics, and structural aspects of proposed facilities and that the water quality factors will be determined by the State and Regional Boards and EPA. Nevertheless, processing an application through the Coastal Commission could result in delays.

State Lands Commission — Permits are required from the Commission for all facilities crossing State lands — those extending from the shoreline to the three-mile limit. To obtain a permit, it is necessary to complete an environmental impact statement and subject the project to an interagency review.

Association of Bay Area Governments — The Association is exercising a regional planning and project approval function. Although ABAG has had a relatively limited role in water quality matters, it can be expected that if strengthened and succeeded by a more powerful regional government — which is likely in the near future — its concern for water quality, particularly for the land use related effects of water and wastewater programs, will be greater.

It is interesting to note that interagency reviews sometimes circulate to as many as 25 agencies. Interagency review is required for waste discharge requirements, a State Lands permit, a Corps of Engineers permit, environmental impact statements, and — presumably — a permit from the newly-formed Coastal Commission.

FINANCIAL ASSISTANCE

Construction Funding

Until this year, Federal grants comprised 55 percent of project cost with 25 percent contributed by the State and 20 percent by local sources. Public Law 92-500 increased the Federal share to 75 percent. Although the law does not require State participation, AB 740 established a State grant of 12½ percent.

The eligible projects now include collection systems, interceptor sewers, pump stations, and outfalls in addition to treatment systems. The definition also includes combined stormwater and sanitary sewer systems, and separate stormwater systems. The costs of facilities necessary to control these sources of pollutants far exceeds the availability of funds. With present policies of the Administration, the $18 billion authorized by Congress is not likely to be appropriated. The likely amount is estimated at $9 or $10 billion over the next three years.

It is anticipated that the following principles will govern future priorities for fund allocation:

- Projects needed to improve effluents where cease and desist orders have been issued and where violation of requirements is significant.
- Projects which result in consolidation of facilities and further regional planning goals.
- Projects which are part of staged improvement programs which will require regular expenditures over long time periods to achieve end results.

This will result in high priority for dry weather facilities for the City of San Francisco. The question remains on the extent to which joint-use facilities, serving both wet and dry weather needs, will receive high priority. It is most unlikely that any grants will be available in the immediate future for separate wet weather facilities.

Although San Francisco has the only major combined sewer system in California (about 12 square miles of such sewers exist in Sacramento), it is not likely that the State will give early high priority for full control of combined wastes. However, it is possible that substantial grant participation can be attained for:

> consolidated wet and dry weather facilities since the cost allocatable to dry weather control is eligible and of high priority; or
>
> a high benefit/cost early stage of the Master Plan.

Demonstration Projects

The law also authorizes grants to any state or municipality for the purpose of research and development of projects which demonstrate new or improved methods of preventing, reducing, or eliminating the discharge of pollutants from sewers which carry stormwaters or combined wastes. For the purposes of research and development, the law authorizes $75 million for Fiscal Year 1973-1974, but it is likely that the Office of Management and Budget will curtail these funds. Emphasis on these types of projects will therefore be limited.

Relationship Between Grants and Enforcement

It is likely that time schedules for enforcement will be adjusted to fit fund availability for the high priority dry weather facilities. It is equally likely that wet weather facilities will not receive grants in the near future. Unless the State and Regional priorities shift from those established in tasks, plans, policies, and requirements, they will demand a certain degree of wet weather control in the immediate future regardless of grant availability.

SUMMARY

Receiving Water and Effluent Quality Requirements

The restrictions which govern receiving water and effluent quality conditions for waste discharges are set forth in five individual waste discharge requirements. Compliance will require secondary treatment of dry weather discharges. Wet weather compliance can be achieved only through drastic reduction of the bypasses in the shoreline areas, or a high level of treatment and disinfection of the combined wastewater prior to discharge.

The recently adopted Federal Water Pollution Control Act requires that all municipal wastes receive secondary treatment before July 1, 1977. Federal regulations defining secondary treatment remain to be formulated.

Treatment at least equivalent to biological secondary will be the minimum acceptable for Bay discharge. Future limitations will probably require filtration or chemical tertiary processes and dechlorination. Continual upgrading of requirements for Bay discharge can be anticipated.

Some form of secondary treatment possibly less costly than biological secondary, is presently required by the State for ocean discharge. It is anticipated that the provisions of the existing State Ocean Plan will be accepted as the maximum treatment needs for long-term discharge to the ocean.

Grant Eligibility and Availability

All facilities contained within the Master Plan are eligible for State and Federal grants, the availability of funds is dependent upon future appropriations. Grant eligibility for wet weather discharges will depend upon cost-effective analysis showing the desired level of control.

State priority lists indicate that funds will not be provided for wet weather control for at least five years. Beyond that time, funds may be allocated depending on national priorities.

Despite State regulations promoting wastewater reclamation and new reclamation emphasis in recent Federal legislation, treatment level and compliance with receiving water standards will continue to be higher priority for State and Federal grants than reclamation. Limited grant funds will result in emphasis on secondary treatment for all dry weather discharges. The availability of funds for a separate dry weather treatment system is reasonably assured if a project is approved for grant participation within the next three years.

Consolidation of the wet and dry weather programs into one all-weather wastewater management system, staged to provide the most cost-effective solution, could maximize State and Federal grant allocations and minimize the City's need for funding separate wet weather facilities.

Compliance of Master Plan With State and Federal Regulations

Combined Overflows — The Master Plan provides for elimination of dry weather discharges to the Bay and virtually eliminates all untreated wet weather discharges. This approach is compatible with the intent of Federal legislation.

Treatment Degree — The higher degree of treatment (secondary treatment) must be achieved by July 1, 1977, to comply with Federal law and cannot be achieved if the Master Plan is implemented without modification.

Discharge Location — The Master Plan provides for ocean discharge rather than Bay discharge. All studies to date and the implication of the State's Ocean Plan as compared with proposed Bay water quality objectives indicate that for a given degree of treatment and assuming proper outfall construction, ocean discharge is far less environmentally harmful than Bay discharge.

Reclamation — The environmental advantages of ocean discharge must be weighed against the possible advantages of a Bay discharge when considering future wastewater reclamation potential.

The Master Plan is compatible with the State's policy that requires consideration of reclamation potential in that future reclamation is not precluded by ocean disposal and no market presently exists for reclamation particularly during winter months. The probability of developing a major reuse scheme for San Francisco that would eliminate the advantages of ocean disposal is virtually nonexistent.

Cost-Effective Program — To achieve dry weather and wet weather goals in the most expeditious and cost-effective manner, it is important for the regulatory agencies to consider the benefits of implementing an all-weather control system rather than concentrating exclusively on a high degree of control of separate dry weather flows.

Chapter VI

THE MASTER PLAN

The wastewater management plan proposed in the Master Plan Report (shown on Figure VI-I) is designed to provide a given degree of control of the combined sanitary sewage and stormwater runoff collected in the City's system. Sanitary sewage has a relatively constant flow rate throughout the year. Stormwater runoff, which occurs at infrequent intervals and highly variable flow rates, increases flows in localized areas by approximately an order of magnitude during nearly half of the storms.

This can be illustrated as follows:

> Average daily flow of sanitary sewage from San Francisco is approximately equivalent to runoff which would be produced by a rainfall of 0.01 inches per hour occuring simultaneously over the entire City. In contrast, 94 percent of the rain, considering the Federal Office Building gage as representative of intensity, occurs at a rate greater than 0.01 inches per hour, and 50 percent of the rain fell at a rate nine times greater than the rainfall equivalent of sanitary flow. However, on an annual basis more flow is contributed by the sanitary flow. During an average year an estimated 81 percent of the total wastewater is sanitary sewage, while 19 percent is stormwater runoff.

Most of the wastewater is of sanitary sewage origin and is discharged during dry weather periods at a relatively constant rate. During rains the waste characteristics vary greatly and normally consist of much higher proportions of stormwater than sanitary sewage. Since San Francisco has a combined sewer system, the effect of these runoff characteristics is a steady, fairly predictable base flow with a superimposed highly variable series of surge flows which occur during a very small percentage of the year. This flow pattern presents numerous problems in the development of an effective system for transportation, treatment, and disposal.

Deleterious material contained in the sanitary and combined wastes which can affect the ocean and Bay environments include:

- Material that is floatable or will become floatable upon discharge.
- Settleable material or substances that form sediments which degrade benthic communities and other aquatic life.
- Substances toxic to aquatic life due to increases in concentrations in water or sediments.
- Substances that significantly decrease the natural light available to benthic communities and other aquatic life.
- Materials that result in aesthetically undesirable discoloration of the water surface.
- Substances that upon discharge result in reduction of dissolved oxygen concentrations and subsequent harm to aquatic life.
- Substances which serve as nutrients for certain aquatic microorganisms thereby stimulating unnatural growth and eutrophication of receiving waters.
- Disease-causing organisms or indicator organisms which represent a real or potential health hazard.

Pollutants contained in wastewaters from sanitary sources and from stormwater runoff have similar characteristics. More specifically, the quality is sufficiently similar that the effects of these wastes on the receiving waters are more dependent on flow patterns than on differences in wastewater quality. As in the case of total flow the major source of pollutant mass emissions annually is the continuous discharge of sanitary sewage. During periods of stormwater runoff the mass emission rates for pollutants is far higher than during dry weather; for some parameters, dramatically higher. However, the short duration limits the impact of these high rate emissions of pollutants.

Differing control methods may be most effective in handling the constant sanitary flows and the variable storm flows. Historically, sanitary flows have been collected and treated to reduce emissions of pollutants and contamination problems while during storm runoff the wastewater that could not be treated was conveyed to the nearest receiving water for discharge. Treatment of these variable storm flows was not considered practical or necessary.

In San Francisco when flows exceed that which can be transported and treated they are discharged at 41 bypass locations scattered around the entire perimeter of the City. The result of these discharges is that the nearshore waters surrounding the entire city are polluted and contaminated to a degree where beaches are aesthetically objectionable and waters are not acceptable for swimming for a significant number of fall, spring, and winter days. These problems are directly related to the wastewater discharge quality and quantity and the location of discharge points.

Solution of the problem, theoretically, can be achieved by treatment of all wastes, by collecting these wastewaters and discharging at a more suitable location, or by various combinations of these alternatives. Since the quantity of pollutants discharged during storms annually is relatively small, the potential for damage to aquatic life is far less than created by dry weather flows. The greatest benefits of storm flow control are related to public health and aesthetics. These uses and the hydrology of storm flow favor collection and transport of the flows to a more acceptable discharge location with whatever treatment is necessary for discharge.

The major water quality problems associated with the dry weather sanitary discharges are related to the constant emission of potentially environmentally hazardous pollutants. Reduction of pollution load and impact on receiving waters can be achieved only by upgraded treatment and careful location of discharge points to minimize concentrations in receiving waters. In San Francisco, the option is available to discharge to the ocean or the Bay. Protection of the ocean environment generally requires a lower level treatment than is necessary to protect the Bay. Emphasis for dry weather control should be directed at both reducing mass emissions and discharging at the optimum available location.

The Master Plan concept incorporates collection, storage, transportation, treatment, and disposal into one overall system designed to achieve the most cost-effective control of all wastewaters. Available information is sufficient to proceed with final design of some elements of the Plan; however, additional information is necessary and is being developed to permit necessary refinements.

GOALS OF THE MASTER PLAN

The following goals are set forth in the Master Plan Report:

"That the treated waste be discharged to the Bay or Ocean through properly designed outfalls so as to have no adverse effect on marine life, the water, or beaches.

"That treatment rate can be varied to meet special flow or available dilution changes.

"That there be flexibility to meet changing water quality requirements and needs for reclaimed wastewater and a 'building block' concept is included to minimize premature abandonments due to changing plans.

"That direction of the City Planning Commission, the Bay Conservation and Development Commission, and other agencies be reflected to avoid adverse effects on the future development of San Francisco, particularly waterfront or water areas and that use of valuable property for treatment facilities be avoided.

"That valuable land such as Golden Gate Park and the north waterfront area be released from sewage treatment use as replacement facilities with multi-use potential are constructed in more appropriate locations.

"That financing of the Plan implementation be feasible and recognize increasing maintenance and operation costs and the time-span relating to San Francisco financing alone or being expedited by Federal and State funding.

"That a cost-benefit relationship be included so that policy on the degree of wet weather treatment can be established.

"That immediate upgrading of the effluents from the treatment plants can be undertaken.

"That substantial reduction in flooding of City streets can be obtained.

"That the degradation of receiving waters by combined overflow be substantially reduced.

"That a viable industrial waste program be provided to control toxic discharges at the source with supplemental treatment as necessary and technically feasible.

"That there be long-range capability for the consolidation of the three treatment plants into one plant.

"That an undue investment in facilities need not be prematurely abandoned if it proves necessary in the next century to prohibit all discharges to the Bay.

"That there be capability to effectuate an agreement for San Francisco to accept effluent from agencies in northern San Mateo County to facilitate a regional consolidation plan.

"That there be compatibility with the anticipated Bay area regional sewerage plan.

"That there be capability of conversion to rail transport of solids (dried sludge) in the event a local or regional rail haul plan for solid waste is implemented.

"That advantage be taken of the City's hilly topography for underground storm storage.

"That there be direction toward a central control system so that dry weather flow, wet weather flow, and street drainage can be managed with high-speed decisions on assignments of flow increments to varying transport and treatment facilities to make the maximum use of available capacity with changing storm patterns."

PROPOSED MASTER PLAN CONCEPT

The general concept of the Master Plan is that there exists a combination of transport, storage, treatment, control, and disposal location which most effectively reduce the detrimental effects of waste discharges from the City. Specific components of the system as proposed in the Master Plan Report are:

- A system of rain gages to monitor a storm continuously as it approaches and traverses the City.
- Continued utilization of combined sanitary and storm sewers throughout the City.
- Consolidation of the existing 41 overflows to 15 shoreline collection points and construction of retention basins at those points. These basins will receive waste from upstream areas, store, and release flows at controlled rates. Wastes from the 15 shoreline basins are released into either the crosstown tunnel or the ocean side transport pipeline.
- Upstream retention basins within most of the 15 major watersheds. These basins will permit regulation of flows to downstream sewers and the 15 shoreline retention basins.
- A crosstown tunnel beinning in the North Point region, extending south into the Southeast drainage area, then turning west to the Lake Merced area. The tunnel will transport all storm and sanitary waste from the north and east portions of the City to the Lake Merced area.
- A major pipeline or tunnel from the southern Presidio boundary south to the Lake Merced area. This line will transport all waste from the west side of San Francisco to the Southwest Treatment Plant near Lake Merced.
- Regional storage facilities associated with the crosstown tunnel to further control flows.
- An all-weather treatment plant (Southwest Treatment Plant) near Lake Merced for sanitary and storm flows designed to operate with split-flow alternative treatment levels depending upon plant inflow.
- A dual-purpose ocean outfall designed to transport dry weather flows four miles and storm flows two miles into the ocean.
- One central computer-operated control system to characterize storms and regulate withdrawal rates from all retention basins.

The locations of the major physical features of the proposed system are shown on Fig. VI-1. Proposed sizing of some components are presented in the Master Plan Report. At the present level of design data, the treatment plant is to serve a maximum flow of 1,000 mgd which is equivalent to run off from 0.1 inches per hour of uniform rainfall over the City. Four storage alternatives are presented. The final selection will be based on available funds and desired level of control of bypassing. The four alternatives provide citywide storage capacities of 9, 18, 33, and 56 million cubic feet. The capacity of the main transport system is not yet determined but is presently sized at a rainfall rate of 0.3 inches per hour from the tributary area with 1,000 mgd maximum. Maximum release rates from the individual retention basins cannot be established without additional data but are preliminarily sized to handle runoff from a rainfall rate of 0.3 inches per hour on the tributary area.

The Master Plan Report proposes operation of these facilities in the following manner:

> Storms will be characterized by a system of rain gages. Control of storage utilization, transport rate, and treatment rate will be based on the spatial and temporal characteristics of the particular storm. Should both the storage and transport capacity from any of the 15 drainage basins be exceeded, overflow from the shoreline retention basins would discharge to the nearest receiving water. Storm flows are stored in retention basins and withdrawn at selected rates for transport to Lake Merced where a portion of the flow receives secondary treatment. Flow above the capacity of the secondary system receives chemical primary treatment prior to blending and discharge. A five-mile outfall is proposed to transport peak dry weather flows and a two-mile outfall to transport flows exceeding 250 mgd.

During dry weather conditions, sanitary sewage will be collected and transported to the single Southwest treatment plant, given secondary level treatment and discharged to the ocean.

To assure adaptability to various treatment needs, the Southwest treatment plant is designed as a split-flow facility. The plant will be designed for easy addition of more advanced treatment processes if needed.

STORAGE

The fundamental purpose of storage in wastewater management is flow control; that is, to provide a means of moderating the high flow rate variations associated with rainfall events. This moderation is accomplished by providing a volumetric capacity (a storage basin) with controlled feed (flow in) and withdrawal (flow out).

When flows in the sewerage system are too high to be treated directly, the feed rate to the basins is increased until the demand ceases or the basin becomes full. When flows in the sewerage system are below the treatment capacity, the basins are dewatered in preparation for the next storm. If high flows continue after a basin is full, an overflow will occur.

As developed in the Master Plan Report the following design features are associated with each basin or tunnel storage unit:

- A means of diverting all sewage flow around the basin during dry weather periods.
- A crude pretreatment of combined flows entering the basin to minimize solids and floatables accumulations within the basins.
- A remotely operated rate control on the filling or bypassing of the basin.
- A remotely operated rate control on the dewatering of the basin.
- Connection of all drainage areas to a single treatment plant (the capacity of the existing interceptors is estimated as equivalent to 0.03 inches per hour of rainfall; whereas the desired withdrawal rate varies from 0.10 to 0.30 inches per hour).

The first two features are primarily designed to avoid or minimize odor and maintenance problems. The third and fourth permit the operational use on a total systems basis and the fifth increases operational flexibility to provide increased relief to areas highly stressed by local cells of intense rainfall.

Storage Location

The Master Plan concept utilizes a combination of three types of storage: upstream basins, shoreline basins, and tunnel storage. The approximate locations of the retention basins, identified by street intersections are listed on Table VI-1.

Upstream Basins — Upstream storage basins have been employed to relieve surface ponding by reducing peak flows to inadequate sewers, thus eliminating or reducing their inadequacy. The upstream basins are located at an elevation that in most cases permits gravity drainage to the outlet sewer. The storage volumes and release rates are dependent upon the areas served and hydraulic capacity of downstream sewers.

This concept is sound for attaining the goals of reducing localized flooding, reducing the inadequacy of sewers, and reducing the rate at which waste must be treated and discharged. Attainment of these goals will require three times more basins than an all shoreline basin system. This will significantly add to the cost of inspection, operation, control and maintenance. Basins will be smaller resulting in increased unit costs. The increased costs and potential operational problems should be evaluated against the benefits of reducing flooding in each drainage basin. The cost should be compared to that of replacing sewers and providing equivalent storage in other portions of the system. These details should be considered for each individual basin and for the combined system during final design.

The use of the peak flow from a five-year storm as computed by the rational method to determine the adequacy of downstream sewers is questionable. The extent and duration of flooding is dependent on the duration as well as the absolute peak flow value. A more appropriate method of determining sewer adequacy and flooding potential is the runoff hydrograph. The need for development of sewer improvement criteria based upon runoff hydrographics is recognized in the Master Plan Report and work is proceeding. Data being collected by the rainfall and sewer monitoring programs will provide the information necessary to determine the adequacy of sewers.

Shoreline Basins — The Master Plan Report proposes to construct shoreline basins at the proposed 15 grouped overflow points. This grouping is logical and effectively reduces the 41 existing overflow points to a manageable number. Withdrawals from the shoreline basins will be pumped to the interceptors or tunnels leading to the Southwest treatment plant during and immediately following storms. Shoreline basins under the Master Plan concept would be reduced in volume by the volume of the upstream basins. The system within an individual drainage basin is designed such that waters containing the highest concentrations of solids and floatables are diverted directly to the interceptor and thus the treatment plant rather than flowing to the shoreline basin. The shoreline retention basins are designed to provide a degree of removal of solids and floatables from any wastes which must be bypassed.

Tunnel Storage — The crosstown tunnel as proposed in the Master Plan Report will convey an estimated 68 percent of San Francisco's storm runoff to the Southwest plant. The tunnel provides both conveyance and storage which permits it to act as an equalization basin ahead of treatment. This is an excellent concept and permits the operational use of spatial and temporal variation of rainfall to greatest advantage. By effectively utilizing this equalization storage and capitalizing on the nonuniformity of rainfall at any point in time, significant reductions in treatment capacity, and perhaps local storage, may be realized.

Storage Volume

The storage volume necessary to contain overflows depends on the peak runoff, the volume and shape of the runoff hydrograph, and the rate of withdrawal from storage to treatment. The runoff hydrograph is related to the rainfall hyetograph if the effect of storage is neglected. Consequently, the 62-year hourly rainfall records of the Federal Office Building gage maintained by the U. S. Weather Bureau and the 21-year hourly record at the Richmond-Sunset gage maintained by the City were analyzed by computer. The average number and volume of overflows, the hours of overflow, and the volume treated in an average year for various combinations of treatment rates, and storage volumes were developed from the analysis. The results permit the plotting of the number of overflows versus storage capacity for treatment rates from 0.02 to 0.10 inches per hour as well as storage capacity versus treatment rate for constant number and volume of overflows.

This type of analysis allows evaluation of the overall effect of the entire yearly rainfall under average conditions on runoff quantity and number and volume of overflows for different treatment rates and storage volumes, including existing conditions of 0.02 inches per hour treatment rate and zero storage. The results of this analysis are shown on Figures VI-2 & 3. When using these figures it is important to note that the treatment rates are expressed as equivalent uniform rainfall rates and the storage volumes, volumes of overflow, and volumes treated are expressed as equivalent inches of rainfall, and that true estimates of volumes and rates require multiplication by an appropriate runoff coefficient. This is assumed to be 0.65 for the City as a whole.

The storage alternatives presented in the Master Plan Report provide storage for 0.15, 0.27, 0.58, and 0.96 inches of uniform rainfall with alternates A, B, C, and D respectively.

While use of the overflow — storage — treatment rate curves and the alternate storage capacities yields an estimate of the degree of control available with various options, the assumptions involved and city wide scope of the relationships limit their usefulness for design purposes. It is unlikely that a uniform degree of control will be selected for the entire city. For example, after examining land use and beach and water recreation areas it becomes apparent that a level of storage between Alternate C and D may be appropriate for overflows discharging to the beaches on the north and west sides. Alternates A or B may be more suitable for overflows located in the dock and commercial areas of the east and northeast sides of the City. The land area available for basins on the western shore is greater than in the commercial areas on the eastern shore so that it would appear that such a variation in criteria is entirely feasible from a contruction standpoint.

The size of the individual storage basins and tunnel storage is shown on Table VI-2 for storage alternates A to D. This plate also gives the number of acres controlled by each basin and the withdrawal rate to treatment in cubic feet per second based on the runoff from a rainfall rate of 0.10 inches per hour on the controlled area and a runoff coefficient of 0.65.

The usefulness of Figures VI-2 and 3 and other similar curves developed from rainfall data currently being gathered must not be overlooked. The estimates become more accurate as the area considered becomes smaller and closer to the raingage on which the curves are based.

An inconsistency in the Master Plan Report has resulted from the use of upstream retention basins for control of localized flooding. On Page V-11 of the Master Plan Report, it is stated that:

> The volume of storage facilities considered must adhere to the following criteria:
>
> (a) the storage volumes utilized shall not be less than 1/2 million cubic feet; this restriction stems from the consideration of economics of the construction of such basins.

Examination of Tables VI-1 and VI-2 indicates that many of the basins are much smaller than 500,000 cubic feet in volume. The unit cost curve on Figure VI-4 is a maximum of $9.00 per cubic foot and rising vertically at a volume of 320,000 cubic feet for upstream basins. No values are given for smaller sizes. Table VI-3 shows for each storage alternate the number of basins larger than 500,000 cubic feet and smaller than 300,000 cubic feet. It will be seen that the smaller basins predominate except for Alternate D. Many of the basins in Alternates A and B are as small as 100,000 cubic feet and many basins in Alternate C are smaller than 200,000 cubic feet.

A source of available storage volume which has not been fully investigated is that available in the wet weather transport system and treatment plant. In considering available volume no allowance is made for storage available at the treatment plant due to empty tanks which must be placed in service, or for storage in the existing sewers or proposed transport conduits. For conceptual analysis this is satisfactory but substantial savings will be realized, and in final design these factors should be considered.

As developed in the basic design data of the Southwest treatment facility, the total volumetric capacity of the primary sedimentation basin allocated for wet weather flows is 5.2 mcf (million cubic feet). This volume compares to the total storage provided in the Master Plan, exclusive of treatment plant storage, of 8.7 mcf in Alternate A to 55 mcf in Alternate D. This additional storage can be most effectively utilized only if the transport capacity from the area of runoff collection through the crosstown and oceanside tunnels to the treatment plant is significantly higher than the preliminary design transport rate (0.1 in/hr). Further consideration should be given to the storage source in the final selection and sizing of the storage and transport system.

In operating the wet weather treatment tanks, small batteries of parallel tanks should be allowed to fill and overflow at their design treatment rate before additional batteries are brought into service. The resultant simultaneous withdrawal of treated effluent as tanks are being filled will increase their effective storage capacity.

Storage Facility Design

Simplified operational schematic drawings of storage basins and tunnel storage as conceived in the Master Plan are shown in Figures VI-5 and VI-6 respectively. Features of the shoreline basins are similar to the upstream basins except for the increased provisions for pumping. The typical arrangement of basins and tunnel storage with respect to the transport and treatment systems is shown in Figure VI-7.

> **Retention Basins** — The conceptual design of an upstream basin is shown on Figure VI-8. A flow control structure allows bypassing of the dry weather flow and some storm flow to a bypass conduit during maintenance and also to eliminate fouling of the basin and possible odors during dry weather. An expansion chamber will be incorporated in all storage facilities to slow the velocity. A dropout in the bottom of this chamber will conduct the normal dry weather flow and the heavier solids during storm flows beneath the basin to a continuation of the sewer downstream, or where practicable, directly to an interceptor. The main storm flow will pass under baffles and over weirs to keep heavy settleable and floatable solids out of the basin. The flow then enters a distributor channel, which during low flow will drop the influent to the bottom of the tank through a manifold of pipes extending across the entire width of the basin to assist in flushing settled solids towards the outlet. The stored flow is withdrawn through controlled gates in the outlet pipes which are located in the bottom of the end wall. The flow passes to the downstream sewer or directly to the interceptor depending on location. When the storage capacity is exceeded, the excess flow will pass over weirs and flow to the downstream sewer, which in the case of shoreline basins leads directly to the receiving waters. A system of washdown pipes, an emergency dewatering pump, automatic control equipment, and ventilating fans are included in a two-story control structure at the outlet end of the basin. In the case of shoreline basins, this structure would contain the pumps for pumping the stored flow to the interceptor, and where practicable, high-level gravity drawoffs.

The last inland basin just across from the wastewater interceptors and all shoreline basins are designed to discharge the concentrated waste flows only to the interceptors. Flows reduced by interception but in excess of basin capacity must first pass through those basins before overflowing and continuing downstream. This method permits only the cleanest waters to overflow in cases where overflows cannot be avoided.

A schematic diagram of the wet weather control system is shown in Figure VI-9. The design shown on Figure VI-8 and described above may be unnecessarily elaborate. This is caused in large measure by the attempt to keep heavy solids and floating material out of the retention basin. An end weir and baffle across the expansion chamber with a side outlet to the bypass conduit for dry weather flow may be sufficient. This would permit flow over the weirs to drop vertically behind a baffle wall instead of through a manifold of pipes. It may be possible to permit the basins to overflow over a concrete end wall instead of into a series of weir troughs.

Tunnel Storage — The Master Plan proposes a crosstown tunnel in rock from the northeast section of the City through high ground at an elevation sufficient to discharge by gravity at the proposed Southwest treatment plant. Storm flow from sewers crossing or adjacent to the route of the tunnel would drop by gravity into enlarged sections of the tunnel serving as storage chambers and storm flows would be pumped from retention basins situated on sewer outlets along the eastern waterfront at suitable rates for treatment into a transport section in the bottom of the tunnel. A perspective cut-away drawing of the tunnel is shown in Figure VI-10 and a schematic cross-section is shown in Figure VI-11. Storage sections of the tunnel would be approximately 32 feet in diameter and the transport section would be equivalent to a 10-foot diameter conduit at the head end increasing to 16 foot diameter at Southwest. Storage sections would be divided into a lower transport section, central storage compartments serving individual watersheds, and an upper section for ventilation, hose-down piping, and access. It is proposed to provide separation of the heavy and floating materials in a separation chamber on the combined sewer and discharge the flow containing this material directly to the transport section with the cleanest water going into the storage chambers. Controlled gates would control the discharge of water from the storage chambers to the transport section at rates suitable for treatment.

The need for a rather complex design for the tunnel has not been demonstrated and it may be practical to provide storage and crosstown transport in a system with fewer possible maintenance and operation problems. Consideration should be given to a tunnel consisting of one section only for the storage and flow of sewage. The sewage could flow through the tunnel at various depths, depending on the flow, the change in depth providing the necessary storage.

Table VI-4 shows the cross-sectional area required for storage and the area required to transport the peak dry weather flow from the tributary area for the several storage alternates. The sum of these two areas determines the average cross-sectional area of a possible simple tunnel design. As the storage fills, transport capacity for the wet weather treatment rate could be automatically established without requiring additional storage area. The table also shows the minimum slope required to maintain suitable velocities. The total fall in the 37,000-foot length of tunnel varies from 15 feet for Alternate A to 6.3 feet for Alternate D.

The nearly vertical walls of the tunnel would be self-cleaning, and the grade of the tunnel would provide self-cleansing velocities for the dry weather flow. This alternative would provide common storage volume for the North Point and Southeast drainage areas. A regulating gate at the tunnel outlet near Southwest may provide the necessary flow control.

It is suggested that every effort be made to simplify the tunnel design to minimize initial cost and potential maintenance and operation problems.

Operation of Basins

The drainage area tributary to the Lincoln Way outfall would contain 10 upstream basins and one shoreline basin. Several of the basins operate in series; for example, the flow from Basin 13-11 also passes through Basin 13-10 and Basin 13-5 on its way to the proposed high level interceptor. The volume of each basin is based on its uncontrolled tributary area; for example, the volume of Basin 13-10 is based on the area tributary to Basin 13-10 minus the area tributary to Basin 13-11 and the volume of Basin 13-5 is based on its total tributary area less the sum of the areas tributary to Basins 13-6, 13-7, 13-8, 13-9, 13-10, and 13-11. On the other hand, the withdrawal rates from storage to treatment must be based on the total tributary area above each basin. However, the volume of the shoreline basin No. 13-1 and its withdrawal rate are both based on the same uncontrolled area since Basins 13-2 and 13-5 both discharge to the proposed high level interceptor instead of to the downstream sewer.

The shoreline basin serves both the Mile Rock sewer and the area tributary to the Lincoln Way sewer not controlled by Basins 13-2 and 13-5; an area of 744 acres contributing normal dry weather flow in addition to the storm flow.

Evaluation of Storage Alternatives

The concept of providing retention basins at various locations throughout the City to equalize flows into the transportation and treatment system and to control localized flooding is sound. The proposed construction of a full-scale retention basin for study purposes is appropriate. The study should include detailed evaluation of actual basin design and consider all possible modifications which would simplify its operation and maintenance. Consideration should be given to placing the full-scale retention basin in an area of critical need such as in the North Shore or Oceanside areas where storm overflow directly affects beaches.

The tunnel storage and transportation system should be evaluated in detail to determine if a less complex design would provide dependable service at less cost and with fewer operation and maintenance problems. Master Plan facilities should be evaluated to assure that the proposed system offers the most economical balance of local storage, transportation, centralized storage, and storage available at the treatment plant.

Localized retention basins included within the Master Plan minimize local flooding problems and provide the necessary storage to equalize flows throughout the system. The extent and frequency of localized flooding is not clearly shown in the Master Plan Report. The importance of this therefore cannot be readily ascertained. The city, however, has evaluated the adequacy of the city's sewers to transport peak flows from a five-year storm and estimated the cost of making necessary improvements. The results of this analysis should be related to flooding to properly evaluate the problem.

If it is feasible to minimize control of localized flooding or, if control can be achieved in other manners such as increased sewerline and pumping capacity, it may be more economical to provide the same level of control with fewer upstream retention basins. The storage provided in the fewer upstream basins could be compensated by additional tunnel storage, thus providing storage in one major facility which can be assigned to any localized storm condition in the tributary area. Evaluation of this variation to the Master Plan would require determination of the engineering and economic changes which would be necessary in local pipeline and pumping facilities to accomplish the objective of the Master Plan. These can be compared with the cost of providing additional tunnel storage.

An analysis can be made by routing the identical series of storms through the modified storage schemes as were applied to the Master Plan alternatives. Particular attention should be given to storms exhibiting pronounced localized behavior. Data being gathered by the rainfall gages, sewer flow meters, and the pilot retention basin study should be applied to define direction toward the final design efforts which would determine the most economical balance between localized and tunnel storage for each watershed.

The Master Plan proposes to construct 11 or 12 (Alternates A and B, C and D respectively) remotely controlled tunnel storage elements along the crosstown tunnel. All of these elements would be combined into one, the tunnel itself, should the single section concept discussed herein be adopted. The advantage of the single section concept is not only the vast reduction of the complex construction and control network but the fact that the storage availability in the single tube would be automatically available to any tributary area requiring it. Since the entire tunnel length would be increased in size, the transport of flows would not be impaired.

TREATMENT

The Master Plan Report studied wet weather treatment from two viewpoints. One considering a dual functioning facility combining both storage and treatment, and the other considering physically separated units.

Dual Functioning [Treatment/Storage] Facilities

The comprehensive report notes that to provide multiple treatment units at the shoreline for maximum storm flows without storage would require large volumes of tankage. For example, at an overflow rate of 1740 gallons per square foot per day (the peak rate selected for the Master Plan's Southwest facility for Level I treatment) and a 10-foot water depth, equivalent to a detention period of 60 minutes, capacities would be required as shown on Table VI-5.

Such volumes would function as storage basins up to the time that the tankage became full, after which the treatment operation would be initiated. Thus the provision of adequate treatment capacity to handle high flow rates also provides large storage volumes.

It is interesting to note that the storage capacity provided under Master Plan Alternate D, which limits overflows to once in 5 years, is 55 million cubic feet, or 70 percent as large as that in Table II-14 for a 5-year storm. Under Master Plan Alternate A the total storage provided is less than 9 million cubic feet or 11 percent of the 5-year dual functioning facility value.

Further complications associated with providing dual storage/treatment units is that they would logically have to be located on the shoreline to fully capture area flows, thereby compounding land acquisition problems. Also the problems of dewatering the basins after storms and solids disposal would still have to be resolved.

Physically Separated Units

The alternative to providing such large

treatment capacities, is to consider the use of storage to retain the excessive flow for treatment through intermediate capacity plants when runoff exceeds the available capacity. The reduction in peak flows can be considerable if the basin has capacity to retain all flow until the peak has passed.

The Master Plan considered treatment capacities varying from 340 mgd (the maximum hydraulic capacity of the existing plants and equivalent to 0.02 inches per hour of rainfall plus the existing dry weather flow) to 1,000 mgd (equivalent to 0.10 inches per hour of rainfall) operating in conjunction with storage. Larger treatment capacities were analyzed with zero storage.

The treatment rate proposed in the Master Plan Report was 1,000 mgd. The proposed plant capacity, while large, is within reason. It amounts to 8 times the projected average dry weather flow, or three times the capacity of the existing plants, and with the help of the storage retention basins will treat combined storm flows many times larger. The plant capacity of 1,000 mgd is the maximum hydraulic capacity, whereas treatment plants are commonly rated at their design treatment capacity for average flows with the hydraulic capability of 1.5 to 3.0 times the average flow.

Proposed Treatment System

A flow diagram of the proposed Southwest treatment facility is shown on Figure VI-12. Data on rainfall characteristics and treatment systems has permitted estimates of the desired treatment plant capacity and treatment processes. Additional rainfall will be analyzed to define the desired treatment capacity and the pilot plant studies will provide information on the most efficient combination of treatment processes. The plant is presently envisioned at a maximum capacity of 1,000 mgd. Initial treatment of the entire flow is proposed to consist of gross solids and grit removal, chemical addition with low-dose ferric chloride, and sedimentation. Following initial treatment, the flow is to be split with a maximum of 250 mgd receiving further treatment and the remainder, up to 750 mgd, being chlorinated and discharged.

The secondary treatment level with a maximum capacity of 250 mgd will be operated continuously treating the entire dry weather flow and the portion of wet weather flow up to 250 mgd. The secondary treatment process is planned to consist of high-dose lime addition followed by flocculation, sedimentation, and recarbonation. Following treatment, the effluent will be chlorinated and discharged. From all available data, these processes appear to be preferred above others; however, they are considered tentative until the outcome of pilot plant studies.

Typical removal efficiencies for various treatment levels used in the Master Plan to determine treatment necessary to produce the desired effluent quality are shown on Plate VI-11 of the Master Plan Report. These removal efficiencies are reasonable for the treatment processes specified. More accurate information will be developed from pilot plant studies.

A single treatment plant was selected because of operational advantages of having one year-round staff and a continuously operating facility. The single facility can also more economically treat runoff from the City, due to its spatial and temporal variation, than can be accomplished by individual treatment systems serving various areas in the City. Individual plants located at the three existing sites would require substantially greater total capacity than a single plant to provide the same level of control of wet weather waste discharges.

The location of the selected disposal site also favors a single treatment facility. For disposal at the southwest corner of the City, wastewater must be conveyed to that area. Since transportation will be available, and operation and maintenance and capital costs are lower per volume treated for large facilities, a single plant in the southwest corner of the City is favored.

The system as proposed will treat all flow conveyed to the treatment plant. No bypass at the plant is included in the plans. It is proposed to discharge all untreated wastes directly from the 15 drainage basins. It is possible for the flow to exceed 1,000 mgd at the plant assuming intensive rainfall in the Richmond-Sunset area as well as the north and east portions of the City. It is more beneficial from a water quality viewpoint to discharge untreated waste through an ocean outfall than to the shoreline area when such are the alternatives. It is therefore recommended that consideration be given to providing a bypass around the plant and into the ocean outfall for flows exceeding 1,000 mgd. The desired capacity could best be determined by an analysis of the cost of the bypass measured against the benefits of further reducing shoreline discharges.

The following statement is taken from the Report:

> "Page VI-2: There is an optimum treatment capacity, storage volume relationship which is dependent upon the relative costs of each. For this analysis the 0.10 inch per hour rate appears to be the breakpoint for optimum treatment for the range of withdrawal and treatment. The equivalent plant capacity for the 0.10 inch per hour rate is 1,000 mgd which is the ultimate Master Plan treatment rate."

The Master Plan Report specified a treatment rate of 1,000 mgd, as being the most cost effective within the range of storage being considered Relationships between effectiveness, storage capacity, and treatment rate are presented in the Report.

However, the cost information used to determine cost-effectiveness is not presented. Examination of the storage-treatment-effectiveness relationship reveals no dramatic changes in effectiveness at 1,000 mgd which would justify its selection regardless of treatment methods to be used. In fact, the curves presented do not show effectiveness for treatment rates greater than 1,000 mgd. Another limitation of these comparisons is the method of determining effectiveness as overflow frequency and volume, assuming uniform rainfall as measured at the Federal Office Building gage. It has been demonstrated that rainfall varies significantly over the City. This variation invalidates use of the uniform rainfall assumption other than for a first-order estimation. Final predesign determination of effectiveness cannot be completed until sufficient data are gathered by the rainfall monitoring program.

The Master Plan Report does not consider the storage benefits available as a part of the split-flow treatment system. Filling of primary clarifiers at selected minimum rates combined with discharging at minimum rates could provide significant additional protection against bypassing. A combined treatment and storage system at the Lake Merced site can serve as dual-purpose facilities for both treatment and storage, thus increasing the benefits of one plant, decreasing the cost allocatable to storage, and generally increasing the cost-effectiveness of the entire system.

TRANSPORTATION

The transport system proposed in the Master Plan includes numerous pump stations, force mains, and connecting sewers. Primary features are three major force mains, two major transport lines, and a dual function ocean outfall. The geographical layout of the proposed transportation system is shown on Figure VI-1. The Report uses a transportation rate equivalent to runoff from 0.1 inches per hour of rainfall on the tributary area for purposes of system cost and effectiveness estimates. This rate has since been revised by the city to the equivalent of runoff from 0.3 inches per hour of rainfall to take advantage of rainfall variation which has been demonstrated during the first stages of the rainfall monitoring program. The sizing of the transportation system is critical to the success of the Master Plan. For the Plan to function as envisioned, the transportation system must have the capability to convey the wastewater from heavily burdened areas in the City at a rate sufficient to relieve pressure, through storage basins, pipelines, and tunnels to the treatment facility. To provide these capabilities, the system must be sized so that all functions can occur when necessary from any individual retention basin to utilize the maximum control available with one integrated system.

The capacity of the transport system will determine the degree to which the treatment plant capacity can be utilized by any drainage area. Along with storage volume, the transport capacity also determines the necessary hydraulic capacity of the treatment plant, and the limitations on discharging through the ocean outfall rather than at the City perimeter. Exactly what these relationships are and what effect they have on the transport system capacity are not clearly specified in the Master Plan Report.

The Report leaves the subject of wastewater transport with only a general discussion of its function in controlling spatially and temporally variable rainfall runoff. The transport capacities of the system are extremely important in an integrated system designed to take advantage of rainfall variation. Capacity must be available for withdrawal of most of the treatment capacity from any one portion of the City and possibly for transport of flows above treatment capacity to the ocean. This last option may prove to be very feasible if additional transport can be made available at little cost.

With total expenditures set at a given limit, maximum cost-effectiveness is attained by combining collection, transportation, storage, treatment, and disposal in the most cost-effective manner. The Master Plan should consider providing additional transportation capacity so that untreated (or minimally treated) bypasses could occur when necessary through the ocean outfalls rather than at the City's periphery.

The Report generally refers to treatment and storage as the two variable means of controlling storm runoff. Because the location of discharge is of great importance in determining the environmental impact of the discharge, transport of the wastewater to a preferable disposal area should also be considered as a method of control. Significant benefit can be realized by disposing of combined sewage through an ocean outfall without treatment or with some minimum treatment rather than discharging at various locations around the City perimeter. The ability of the offshore ocean waters to assimilate this type of batch discharge without damage is much greater than the nearshore water. Certainly a deep ocean discharge of contaminated water is preferable to a series of discharges of equal quality around the City's boundary.

The optimum sizing of the transport, storage, and treatment facilities is dependent on the variability of rainfall. The necessary information is presently being gathered to permit sizing of facilities and will soon be available. Since the usefulness of the other components of the Master Plan are limited without the transportation system, it may be necessary to proceed with design of transportation system sized at a level reasonably assured of being adequate. A rate equivalent to runoff from 0.3 inches per hour of rainfall appears to be sufficiently large to provide such assurance.

CONTROL SYSTEM

As envisioned in the Master Plan Report, a centrally located advance information system will be utilized for planning, monitoring, and control of the Master Plan elements. That system, part of which is already in existence, is planned to operate in the following sequence:

- Rain measuring stations located throughout the City and possibly in surrounding areas such as Marin County and the Farallones Islands will transmit actual recorded rainfall data every fifteen seconds to the central control station.
- Monitors located at critical control points in the sewer system will transmit data on actual flow rates to the central control station.
- The central station will record and analyze the data for three purposes:
    1. To provide information on rainfall characteristics to allow selection of probable operating mode early in the storm.
    2. To provide information for control of storage and transmission rates for each individual watershed based on actual runoff data. The system is designed to provide maximum efficiencies from available storage facilities.
    3. To provide data for future system planning and refinement of operating criteria.

Sensing Devices

The centrally located control system relies on sensing devices to measure rainfall and flow which have been developed to a reasonably high degree of reliability and accuracy by San Francisco. Signals are transmitted by telephone lines which could present reliability problems. A system of parallel lines or alternate route systems could increase reliability but is not considered necessary at this time.

Central Control

The information collected at the central receiving station is continuously fed into computers for the purposes listed above. The computers can print a visual image of the storm pattern at any time. When this information is received, the individual storage or transport facilities are instructed either manually or automatically to operate in a particular fashion. For example, when a rainfall is intense in one area of the City local retention basins can be opened to receive wastewater, and as the storm moves across the City these reservoirs can be emptied or remain full depending upon the need to assign treatment or transport capacity to other areas of the City.

System Operation

It is proposed that operational signals also would be transmitted on leased telephone line and the equipment that would be instructed to operate from the central control system would include large numbers and varying sizes and types of valves and pumps. The reliability of remote-control operation for 30 upstream retention basins, 15 shoreline retention basins, the crosstown tunnel storage system, and portions of the treatment plants is a complicated subject. The proposed study of retention basin operation and centralized automatic controls should provide answers to the following questions which are essential prior to system design:

- The reliability of information circuits and the advantages and disadvantages of using radio signals, leased-line telephone circuitry, or a completely independent circuit.
- The reliability of circuitry and control system equipment for operation of valves and pumps from one central remote location.
- The accuracy of prediction under computer-controlled automatic operation.
- The system response rate.
- The risks at each point in the system of control-system malfunction and the need for backup safety features.
- The potential problems and liability that may result from system malfunctions in terms of flooding, unnecessary bypassing, or transportation system overloading.
- A comparison of the cost, realiability, and effectiveness of the proposed control system with a mechanically and hydraulically controlled system which responds automatically

to storm conditions in localized areas without external control. The latter system would be designed based on probabilities of rainfall rates.

Operation Responsibility

To be effective it is essential that the complete control system be fully managed and operated by the department responsible for wastewater management. Dependence upon other departments and private firms with other responsibilities will greatly reduce reliability unless very carefully managed. Operational technical functions in the use of computers, transmission equipment, etc., are secondary support functions essential to effective utilization of the system to achieve the most efficient water quality control during any storm period. Maximum benefit should be made of information provided by the monitoring system to permit the development of effective programs that reflect real system problems.

Necessity

Some form of remote automated information and control system is desirable for operation of the Master Plan. The concept is sound but the many intricacies and potential problems should be resolved and tested at the earliest possible date.

The proposed system may be overly complex and result in unnecessary maintenance and operation problems. It may be adequate to provide a float-operated gate on the bypass conduit and one or more self-contained rate controllers on the basin outlets, depending on the capacity required. In the case of shoreline basins, a float-operated gate on the connection to the interceptor and programmed pump operation sensitive to interceptor and retention basin water levels may be adequate to control the discharge to the treatment facilities.

Each change in the design of storage and transmission facilities that simplifies the operational needs will add greatly to the reliability of the overall system. Every effort should be made to incorporate modifications in the system which will increase reliability without significantly sacrificing control. Reductions in numbers of upstream retention basins, increases in storage capacity in the crosstown tunnels, and simplification of tunnel and retention basin design will greatly reduce the complexity of the control system.

SUMMARY

The treatment rates, pumping rates, storage volumes and locations, and transportation system capacity are closely integrated into one overall cost-effective control plan. Unit sizes have not yet been determined and work is proceeding to analyze rainfall data to permit this analysis. A decision is necessary regarding the advantages of bypassing through an ocean outfall at the treatment plant compared to bypassing at the shoreline from the retention basins to permit sizing of the transportation system and ocean outfalls.

TABLE VI-1 RETENTION BASIN DIMENSIONS

Box No.	LOCATION	ALTERNATE A				ALTERNATE B				ALTERNATE C				ALTERNATE D			
		Length (ft)	Width (ft)	Depth (ft)	Volume ft^3x10^6	Length (ft)	Width (ft)	Depth (ft)	Volume ft^3x10^6	Length (ft)	Width (ft)	Depth (ft)	Volume ft^3x10^6	Length (ft)	Width (ft)	Depth (ft)	Volume ft^3x10^6
	RICHMOND-SUNSET																
11-1 (P)	John Muir Drive Pump Station	102	60	18	0.11	102	60	18	0.11	222	60	18	0.24	247	90	18	0.40
11-5	Brotherhood Way and Thomas More					76	75	30	0.17	160	75	30	0.36	197	100	30	0.59
12-1 (P)	Vicente and Great Highway	94	50	30	0.14	167	50	30	0.25	240	75	30	0.54	294	100	30	0.88
12-2	Vicente and Sunset Blvd.	196	75	17	0.25	361	75	17	0.44	373	150	17	0.95	462	200	17	1.57
12-3	Ulloa and 22nd Avenue					52	60	32	0.10	99	60	32	0.19	162	60	32	0.31
12-4	Eucalyptus and Melba	45	75	30	0.10	67	75	30	0.15	143	75	30	0.32	177	100	30	0.53
12-5	Wawona and Ulloa	85	50	26	0.11	146	50	26	0.19	308	50	26	0.40	508	50	26	0.66
13-1 (P)	Lincoln Way and Great Highway	180	100	30	0.54	180	100	30	0.54	252	150	30	1.13	307	200	30	1.84
13-2	Lawton and 41st Avenue	70	60	24	0.10	91	60	24	0.13	188	60	24	0.27	313	60	24	0.45
13-3	Pacheco and 35th Avenue					42	60	40	0.10	75	60	40	0.18	121	60	40	0.29
13-4	Santiago and 29th Avenue					53	60	32	0.10	94	60	32	0.18	157	60	32	0.30
13-5	Lincoln Way and 39th Avenue	195	100	20	0.39	234	150	20	0.70	363	200	20	1.45	484	250	20	2.42
13-6	Kirkham and 30th					72	50	28	0.10	164	50	28	0.23	264	50	28	0.37
13-7	Noriega and 29th	77	50	26	0.10	77	50	26	0.10	116	50	26	0.15	185	50	26	0.24
13-8	Noriega and 20th	154	25	26	0.10	154	25	26	0.10	162	50	26	0.21	270	50	26	0.35
13-9	Kirham and 12th Avenue					178	25	27	0.12	186	50	27	0.25	296	50	27	0.40
13-10	Judah and 7th Avenue	69	50	32	0.11	69	50	32	0.11	144	50	32	0.23	232	50	32	0.37
13-11	Clarendon and 7th Avenue					211	40	32	0.27	446	40	32	0.57	470	60	32	0.93
14-1 (P)	Fulton and La Playa	135	60	17	0.14	135	60	17	0.14	135	60	17	0.14	135	60	17	0.14
14-2 (P)	Fulton and 48th Avenue	184	60	19	0.21	333	60	19	0.38	346	120	19	0.79	570	120	19	1.30
16-1 (P)	Sea Cliff Outfall	123	60	30	0.22	123	60	30	0.22	123	60	30	0.22	123	60	30	0.22
16-2	Lake and 24th Avenue	111	60	15	0.10	111	60	15	0.10	145	60	15	0.13	234	60	15	0.21
16-3	Lake and 22nd Avenue	119	60	14	0.10	119	60	14	0.10	191	60	14	0.16	357	60	14	0.27
15-4	Lake and 17th Avenue	118	60	17	0.12	118	60	17	0.12	235	60	17	0.24	392	60	17	0.40
16-5	Lake and 14th Avenue									478	120	19	1.09	785	120	19	1.79
16-6	Lake and 8th Avenue					183	50	37	0.32	357	50	37	0.66	590	50	37	1.09
16-7	California and 28th Avenue	50	50	40	0.10	50	50	40	0.10	90	50	40	0.18	150	50	40	0.30
16-8	Geary and 23rd Avenue					187	25	30	0.14	200	50	30	0.30	327	50	30	0.49
	NORTH POINT	R.S. - VOL. Sub Total			3.04				5.42				11.76				19.11
21-1 (P)	Marina Outfall	111	60	30	0.20	206	60	30	0.37	286	90	30	0.77	353	120	30	1.27
21-2	Baker and Union	63	50	32	0.10	63	50	32	0.10	100	50	32	0.16	163	50	32	0.26
21-3	Steiner and Green					49	60	34	0.10	79	60	34	0.16	127	60	34	0.26
21-4	Lombard and Franklin	80	60	25	0.12	140	60	25	0.21	294	60	25	0.44	474	60	25	0.72
24-1 (P)	Beach St. Outfall	89	60	30	0.16	156	60	30	0.28	219	90	30	0.59	270	120	30	0.97
24-2	Columbus and Union									62	60	35	0.13	105	60	35	0.22
24-3	Pacific and Stockton					72	40	35	0.10	100	40	35	0.14	172	40	35	0.24
28-1 (P)	Jackson Street Outfall	96	60	35	0.20	172	60	35	0.36	242	90	35	0.76	296	120	35	1.24
30-1 (P)	Brannan Outfall	67	50	30	0.10	120	50	30	0.18	174	75	30	0.39	210	100	30	0.63
37-1 (P)	Division St. Outfall	302	90	35	0.95	543	90	35	1.71	686	150	35	3.60	937	180	35	5.90
37-2	Valencia and 20th Street	193	20	26	0.10	193	20	26	0.10	221	40	26	0.23	366	40	26	0.38
37-6	Mason and O'Farrell					58	60	32	0.11	58	60	32	0.11	99	60	32	0.19
	SOUTHEAST	N.P. VOL. SUB. TOTAL			1.93				3.62				7.48				12.28
40-1 (P)	Mariposa Outfall	111	30	30	0.10	178	30	30	0.16	189	60	30	0.34	312	60	30	0.56
44-1 (P)	Selby Outfall	166	150	35	0.87	300	150	35	1.57	473	200	35	3.31	517	300	35	5.42
48-1 (P)	Evans and Griffith	125	40	20	0.10	188	40	20	0.15	188	40	20	0.15	188	40	20	0.15
52-1 (P)	Yosemite Outfall	117	100	30	0.35	204	100	30	0.61	222	200	30	1.33	364	200	30	2.18
52-2	Sommerset and Wayland	104	40	26	0.15	181	40	26	0.26	539	40	26	0.56	875	40	26	0.91
54-1 (P)	Sunnydale and Bayshore	143	60	35	0.30	257	60	35	0.54	360	90	35	1.13	441	120	35	1.85
		S.E. VOL. Sub Total			1.89				3.33				6.91				11.22
	(P) Pumped	TOTAL			6.98				12.62				26.68				43.47

Reference 2-Plate VII-4

TABLE VI-2

MASTER PLAN REQUIRED STORAGE

BASIN #	ACRES CONTROLLED	TREATMENT RATE IN CFS 0.10 IN/HR	VOLUME MILLION CUBIC FEET ALTERNATE A [16%]	ALTERNATE B [29%]	ALTERNATE C [61%]	ALTERNATE D [100%]
11-1 (P) (cc)	165	10.9	0.11	0.11	0.24	0.40
11-2 (P)	182	12.0	---	0.13(T)	0.27(T)	0.44(T)
11-3 (cc)	175	11.6	0.12	0.12	0.26	0.42
11-4 (cc)	761	50.2	0.29(T)	0.53(T)	1.10(T)	1.82(T)
11-5 (P)	246	16.2	---	0.17	0.36	0.59
12-1 (P) (cc)	370	24.4	0.14	0.25	0.54	0.88
12-2 (cc)	655	43.2	0.25	0.46	0.95	1.57
12-3	129	8.5	---	0.10	0.19	0.31
12-4	222	14.5	0.10	0.15	0.32	0.53
12-5	276	18.2	0.11	0.19	0.40	0.66
13-1 (P) (cc)	770	50.8	0.54	0.54	1.13	1.84
13-2 (cc)	186	12.5	0.10	0.13	0.27	0.45
13-3	122	8.1	---	0.10	0.18	0.29
13-4	126	8.3	---	0.10	0.18	0.30
13-5 (cc)	1012	66.8	0.39	9.70	1.45	2.42
13-6	154	10.2	---	0.10	0.23	0.37
13-7	101	6.7	0.10	0.10	0.15	0.24
13-8	145	9.6	0.10	0.10	0.21	0.35
13-9	165	10.9	---	0.12	0.25	0.40
13-10	153	10.1	0.11	0.11	0.23	0.37
13-11	387	25.5	---	0.27	0.57	0.93
14-1 (P) (cc)	60	4.0	0.14	0.14	0.14	0.14
14-2 (P) (cc)	541	35.7	0.21	0.38	0.79	1.30
16-1 (P) (cc)	90	5.9	0.22	0.22	0.22	0.22
16-2 (cc)	88	5.8	0.10	0.10	0.13	0.21
16-3 (cc)	112	7.4	0.10	0.10	0.16	0.27
16-4 (cc)	168	11.1	0.12	0.12	0.24	0.40
16-5	748	49.4	---	---	1.09	1.79
16-6	456	30.1	---	0.32	0.66	1.09
16-7 (cc)	124	8.2	0.10	0.10	0.18	0.30
16-8	204	13.5	---	0.14	0.30	0.49
RS SUBTOTAL	9093	600.3	3.45	6.20	13.39	21.78
21-1 (P) (cc)	529	34.9	0.20	0.37	0.77	1.27
21-2 (P)	109	7.2	0.10	0.10	0.16	0.26
21-3 (P)	108	7.1	---	0.10	0.16	0.26
21-4 (P)	299	19.7	0.12	0.21	0.44	0.72
24-1 (P) (cc)	405	26.7	0.16	0.28	0.59	0.97
24-2 (P)	90	5.9	---	---	0.13	0.22
24-3 (P)	102	6.7	---	0.10	0.14	0.24
28-1 (P) (cc)	517	34.1	0.20	0.36	0.76	1.24
30-1((P) (cc)	262	17.3	0.10	0.18	0.39	0.63
37-1 (P) (cc)	2463	162.6	0.95	1.71	3.60	5.90
37-2 (cc) (P)	161	10.6	0.10	0.10	0.23	0.38
37-3 (cc)	303	20.0	0.12(T)	0.21(T)	0.45(T)	0.73(T)
37-4 (cc)	111	7.4	0.10(T)	0.10(T)	0.16(T)	0.27(T)
37-5 (cc)	923	60.9	0.35(T)	0.63(T)	1.33(T)	2.18(T)
37-6 (P)	80	5.3	---	0.11	0.11	0.19
37-7 (cc)	330	21.8	0.13(T)	0.23(T)	0.48(T)	0.79(T)
37-8 (cc)	271	17.9	0.10(T)	0.19(T)	0.40(T)	0.65(T)
37-9 (cc)	453	29.9	0.17(T)	0.32(T)	0.67(T)	1.09(T)
NP SUBTOTAL	7516	496.0	2.90	5.29	10.98	17.19
40-1 (P) (cc)	235	15.5	0.10	0.16	0.34	0.56
44-1 (P) (cc)	2328	153.7	0.87	1.57	3.31	5.42
44-2 (cc)	220	14.5	0.10	0.15	0.32	0.53
44-3 (cc)	469	31.0	0.18(T)	0.32(T)	0.68(T)	1.12(T)
44-5 (cc)	2289	151.1	0.87(T)	1.59(T)	3.34(T)	5.47(T)
48-1 (P)m(cc)	62	4.1	0.10	0.15	0.15	0.15
52-1 (P) (cc)	911	60.1	0.35	0.61	1.33	2.18
52-2 (P)	378	24.9	0.15	0.26	0.56	0.91
54-1 (P) (cc)	774	51.0	0.30	0.54	1.13	1.85
SE SUBTOTAL	7666	505.9	3.04	5.39	11.25	18.11
TOTALS	24,275	1604.4	9.39	16.88	35.62	57.96

(P) - Pumped
(cc) - Control Critical Basin
(T) - Tunnel

Reference 2-Plate VII-3

TABLE VI-3

RETENTION BASIN AND TUNNEL STORAGE

	Storage Alternate			
	A	B	C	D
Retention Basins*				
Number	32	42	46	46
Number larger than 500,000 cf	2	4	15	21
Number smaller than 300,000 cf	27	30	24	14
Storage Volume in Basins* Mil.cf	64	11.79	24.37	39.91
Tunnel Storage** Mil. cf	2.51	4.62	9.76	15.98
Total Storage, Mil. cf	9.15	16.41	34.13	55.89
Percent Tunnel Storage	27.4	28.2	28.6	28.6
Acre Feet of Storage	210	376	784	1280
Inches of runoff stored	105	.188	.391	.640
Inches of rainfall (65% collected)	.16	.29	.60	.99

*From Plate VII-4

**From Plate VII-3, assuming basins 37-3, 4, 5, 7, 8, 9 are tunnel storage in all plans

TABLE VI-4

TUNNEL STORAGE

	Storage Alternate			
	A	B	C	D
Tunnel Storage Required, Mil. cu. ft.	2.51	4.62	9.76	15.98
Avg. Sectional Area Required for Storage, sg. ft*	68	125	264	432
Area Required for Peak Dry Weather Flow**	65	65	65	65
Avg. Area Required, sg. ft.	133	190	329	497
Avg. Diameter Required, ft***	13	15.7	20.5	25.2
Slope Required for 5.0 fps Velocity at n = .013 Flowing Full	.00040	.00031	.00022	.00017

*Based on a length of 37,000 ft

**1.5x the projected average flow of 98 mgd from the North Point and Southeast treatment plant zones at 3.5 fps

***Minimum diameter required at outlet end to transport combined flow treatment rate of 991 cfs (Plate VII-5) from North Point and Southeast Treatment Plant zones at 5.0 fps velocity is 16 ft.

TABLE VI-5

TREATMENT CAPACITIES BASED ON LIMITING OVERFLOW RATE

Storm Frequency	Volume
5 yr.	79 mil cu ft
10 yr.	94 mil cu ft
25 yr.	111 mil cu ft
50 yr.	119 mil cu ft
100 yr.	139 mil cu ft

Figure VI-1

PROPOSED MASTER PLAN

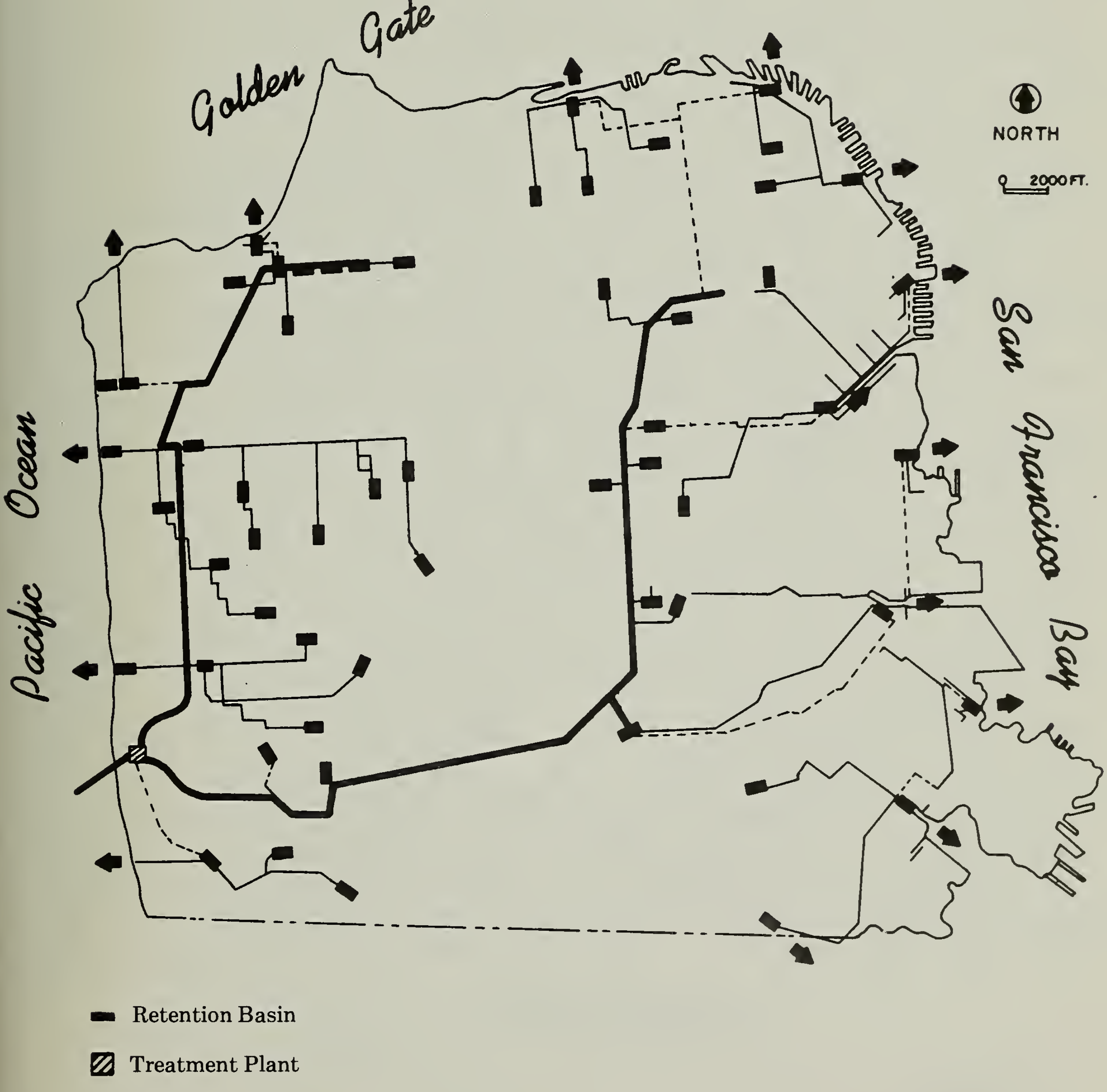
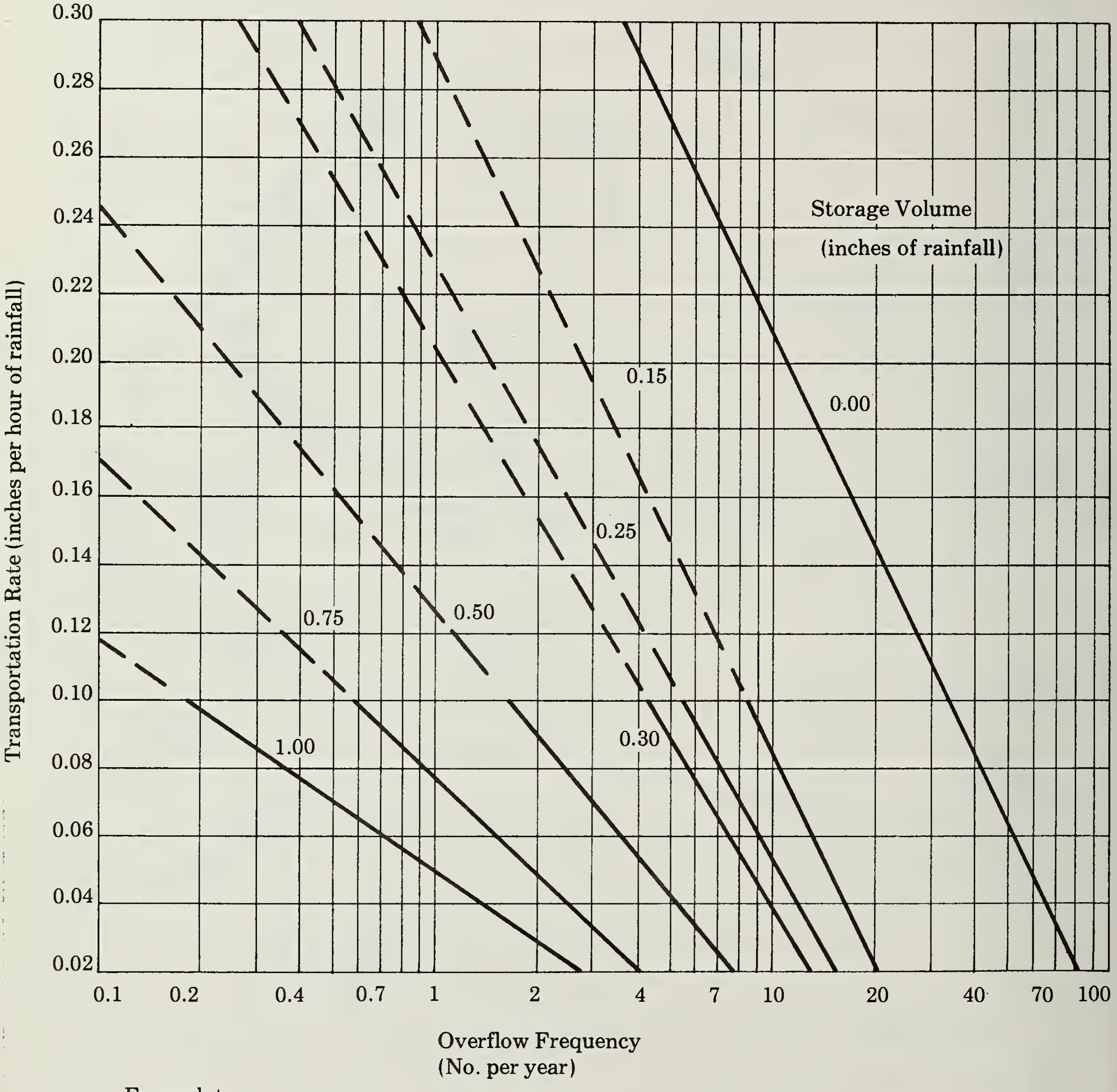


Figure VI-2

OVERFLOW FREQUENCY FOR VARIOUS TRANSPORTATION RATES AND STORAGE VOLUMES

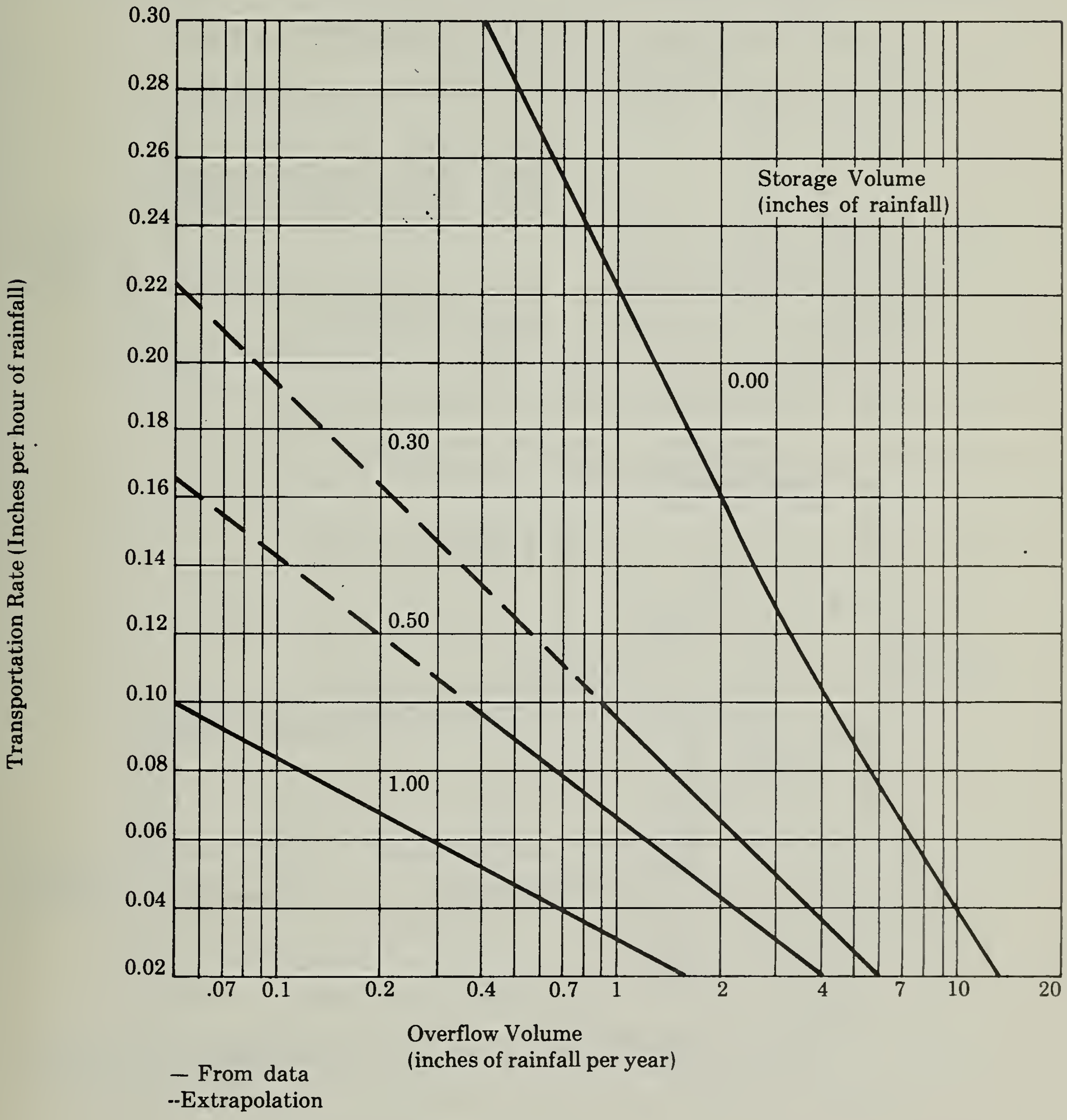


— From data
-- Extrapolation

Reference 30-Section 11

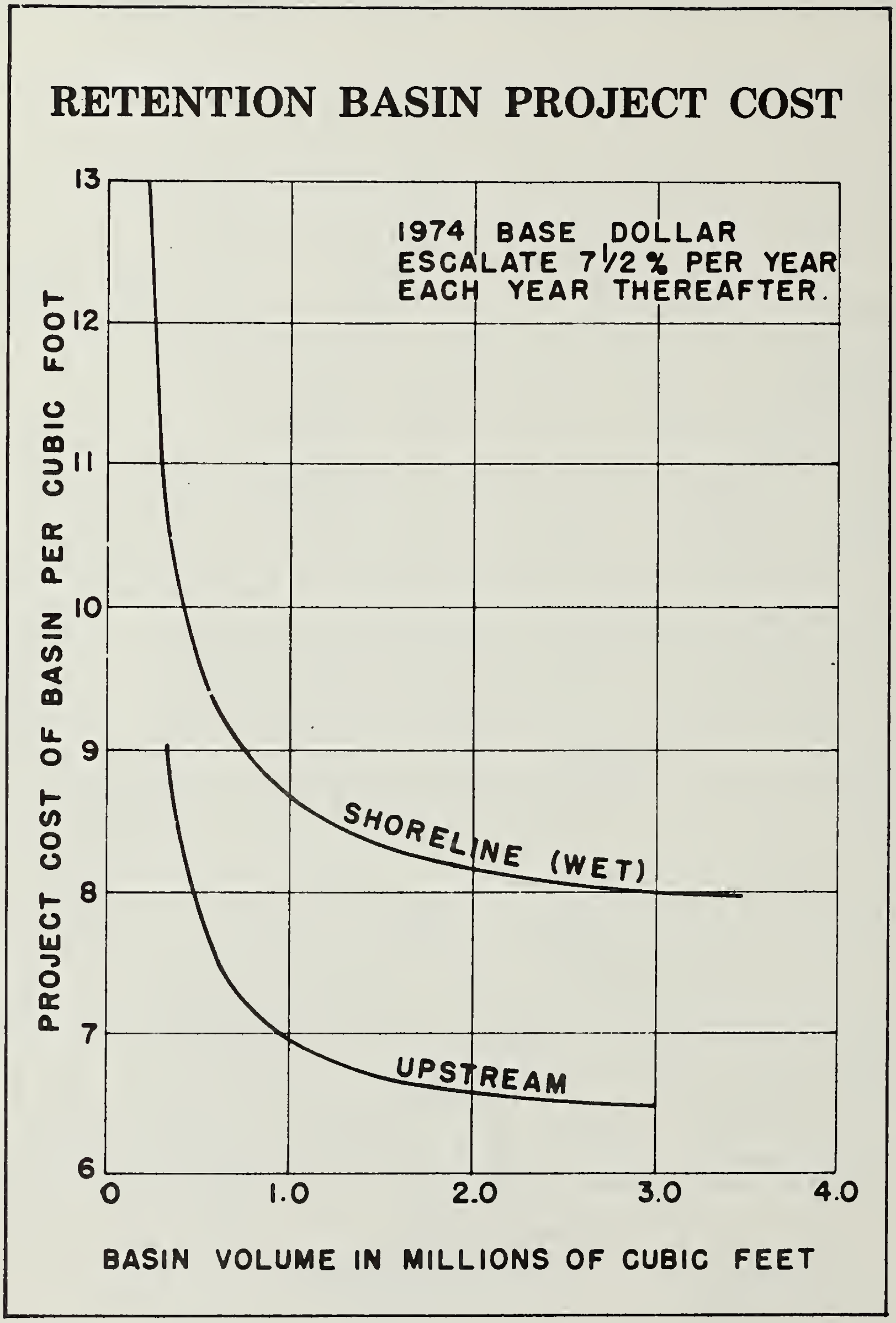
FIGURE VI-3

OVERFLOW VOLUMES FOR VARIOUS TRANSPORTATION RATES AND STORAGE VOLUMES



Reference 30 — Section 11

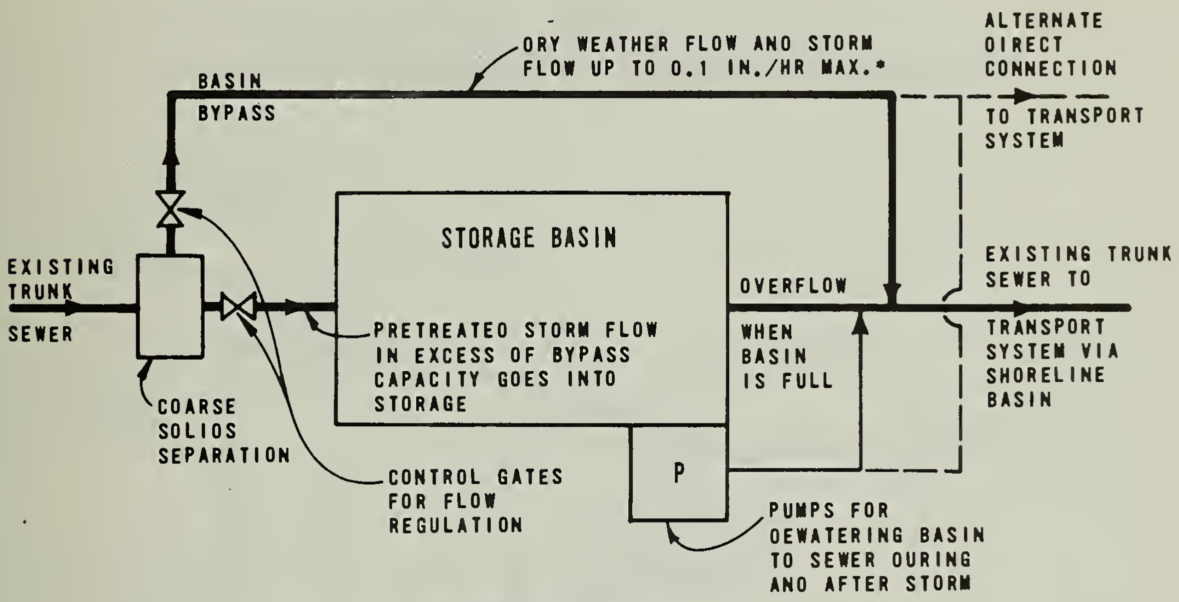
FIGURE VI-4



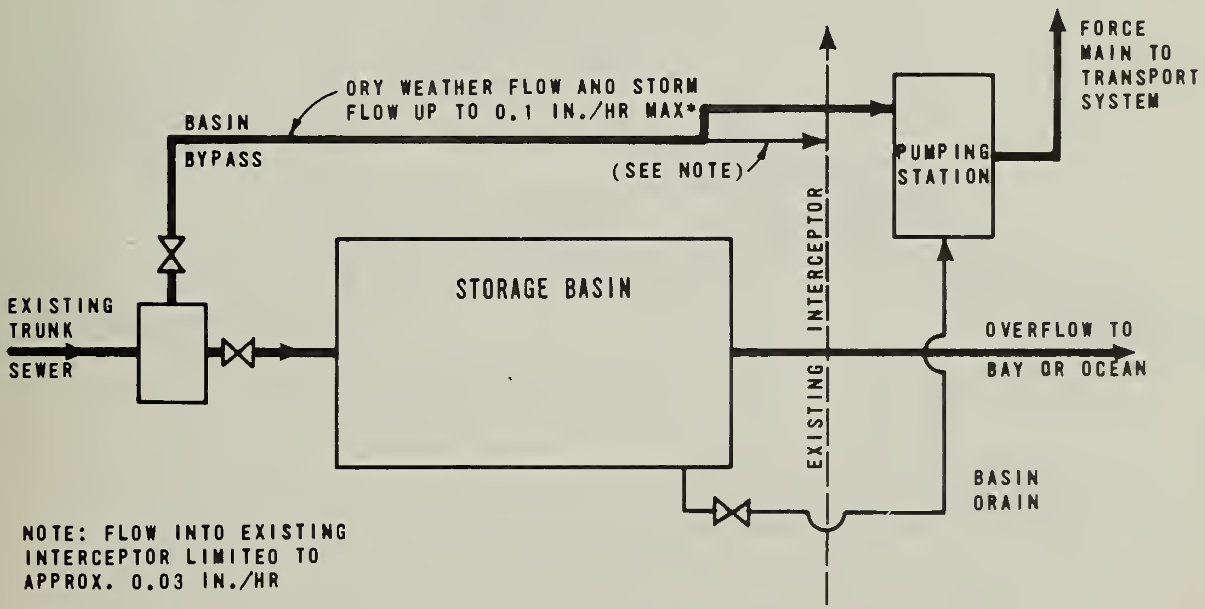
Reference 2-Plate VI-6

Figure VI-5

SIMPLIFIED OPERATIONAL SCHEMATIC DRAWINGS


DRY WEATHER FLOW AND STORM FLOW UP TO 0.1 IN./HR MAX.*
ALTERNATE DIRECT CONNECTION TO TRANSPORT SYSTEM
BASIN BYPASS
STORAGE BASIN
EXISTING TRUNK SEWER
OVERFLOW WHEN BASIN IS FULL
EXISTING TRUNK SEWER TO TRANSPORT SYSTEM VIA SHORELINE BASIN
PRETREATED STORM FLOW IN EXCESS OF BYPASS CAPACITY GOES INTO STORAGE
COARSE SOLIDS SEPARATION
CONTROL GATES FOR FLOW REGULATION
P
PUMPS FOR DEWATERING BASIN TO SEWER DURING AND AFTER STORM

TYPICAL UPSTREAM BASIN



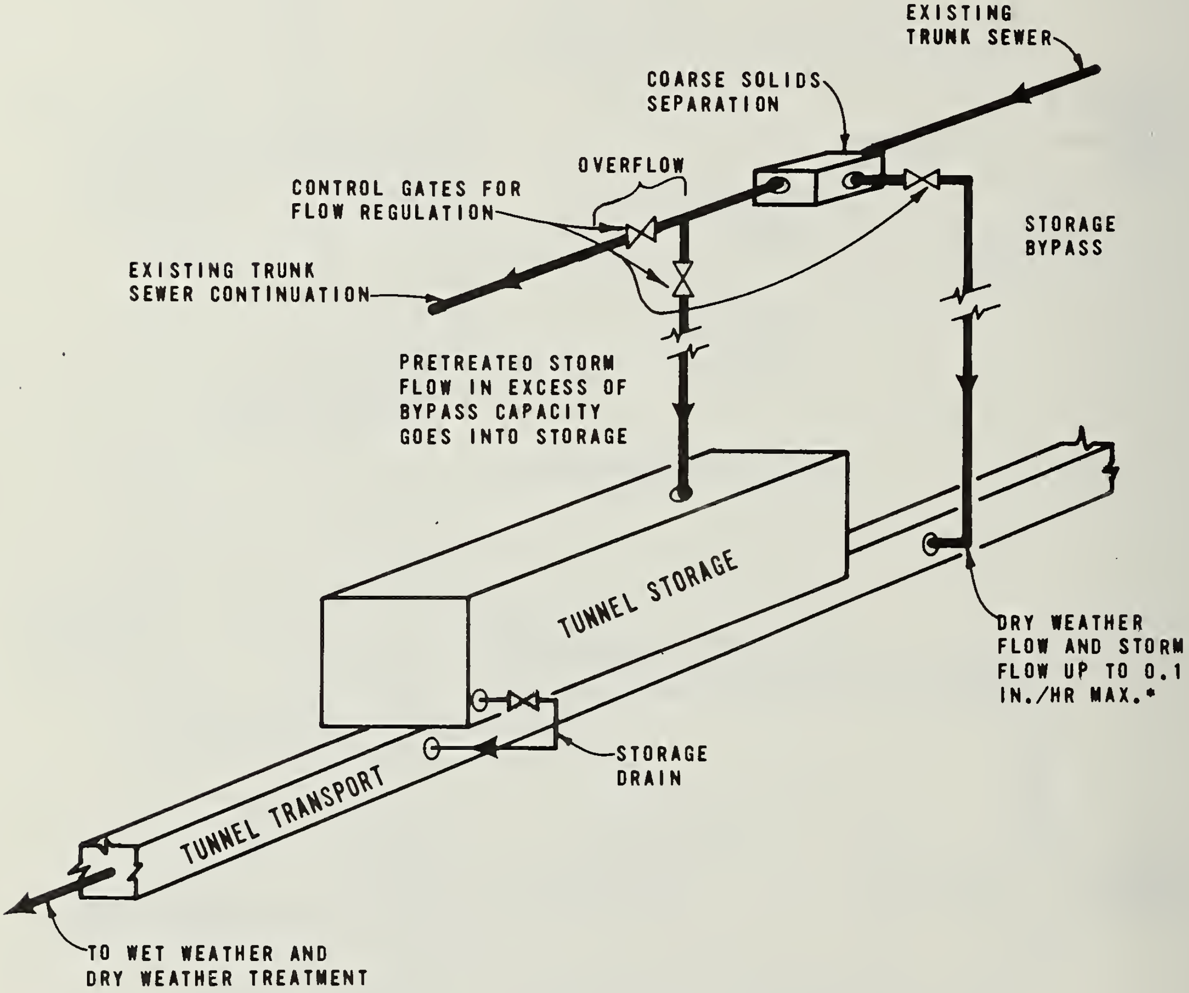
NOTE: FLOW INTO EXISTING INTERCEPTOR LIMITED TO APPROX. 0.03 IN./HR

TYPICAL SHORELINE BASIN

* MODIFIED SYSTEM WILL ALLOW UP TO 0.3 IN./HR

Figure VI-6

SIMPLIFIED OPERATIONAL SCHEMATIC OF TUNNEL STORAGE

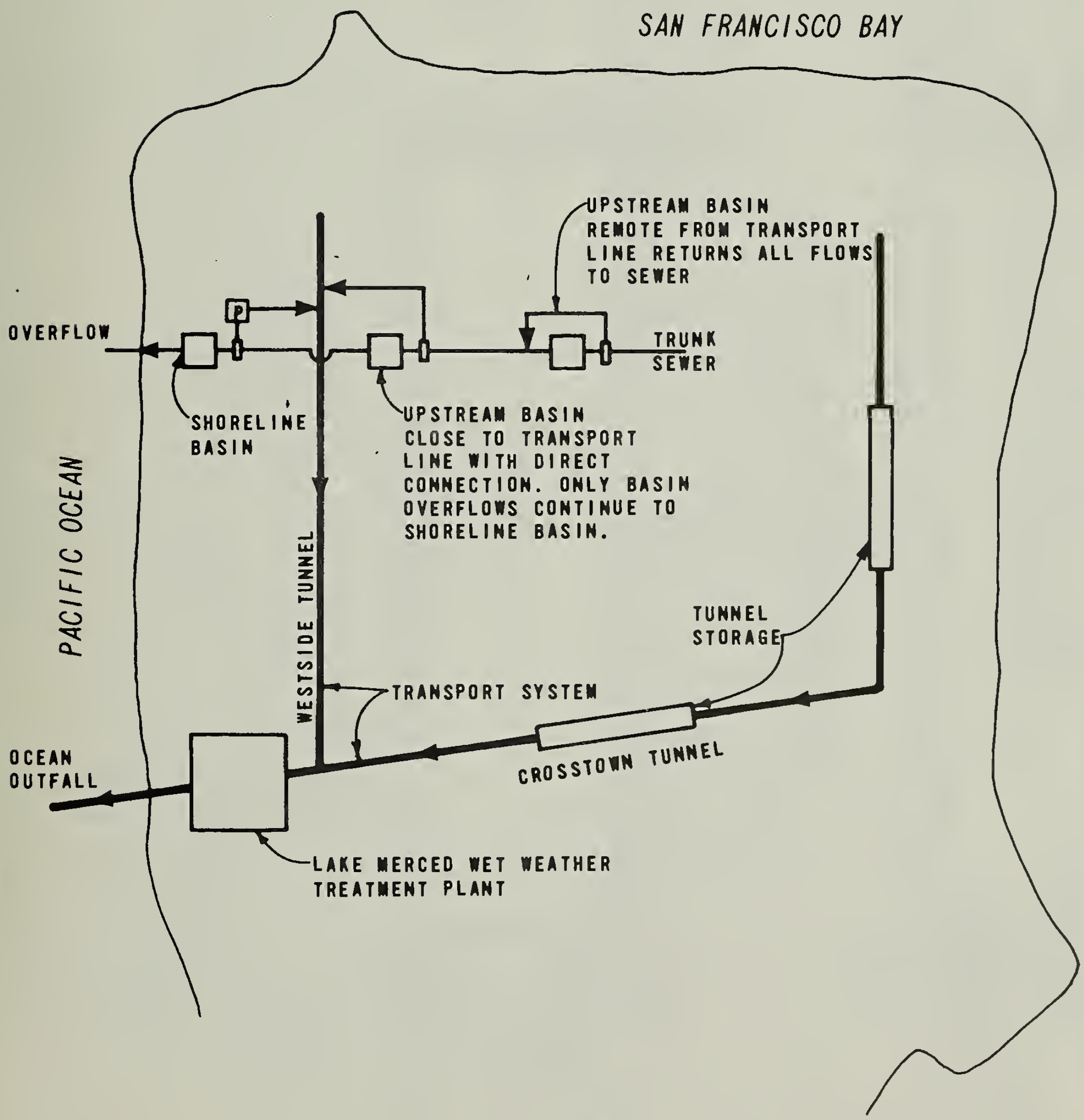

EXISTING TRUNK SEWER
COARSE SOLIDS SEPARATION
OVERFLOW
CONTROL GATES FOR FLOW REGULATION
STORAGE BYPASS
EXISTING TRUNK SEWER CONTINUATION
PRETREATED STORM FLOW IN EXCESS OF BYPASS CAPACITY GOES INTO STORAGE
TUNNEL STORAGE
DRY WEATHER FLOW AND STORM FLOW UP TO 0.1 IN./HR MAX.*
STORAGE DRAIN
TUNNEL TRANSPORT
TO WET WEATHER AND DRY WEATHER TREATMENT

---

* MODIFIED SYSTEM WILL ALLOW UP TO 0.3 IN./HR

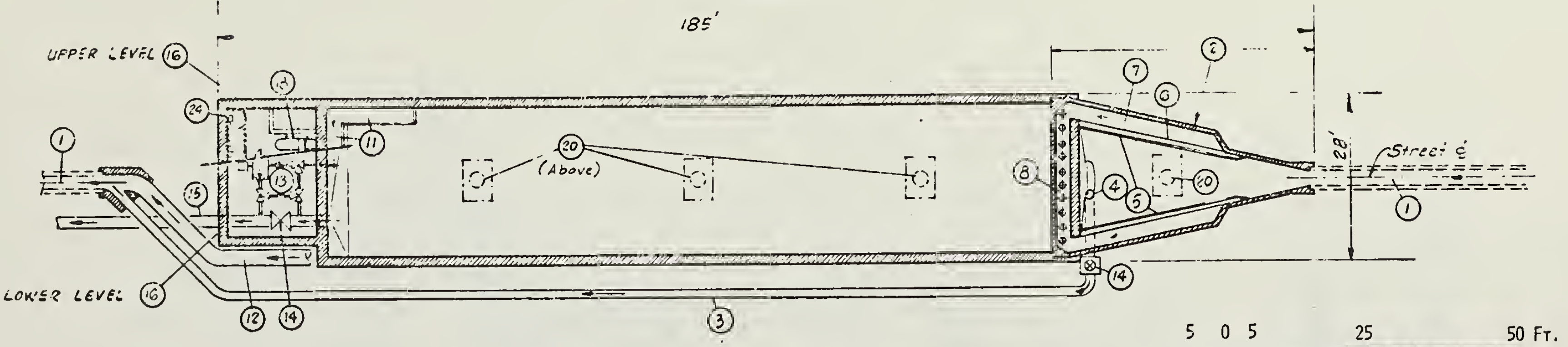
Figure VI-7

CONCEPTUAL BASIN AND TUNNEL STORAGE ARRANGEMENT

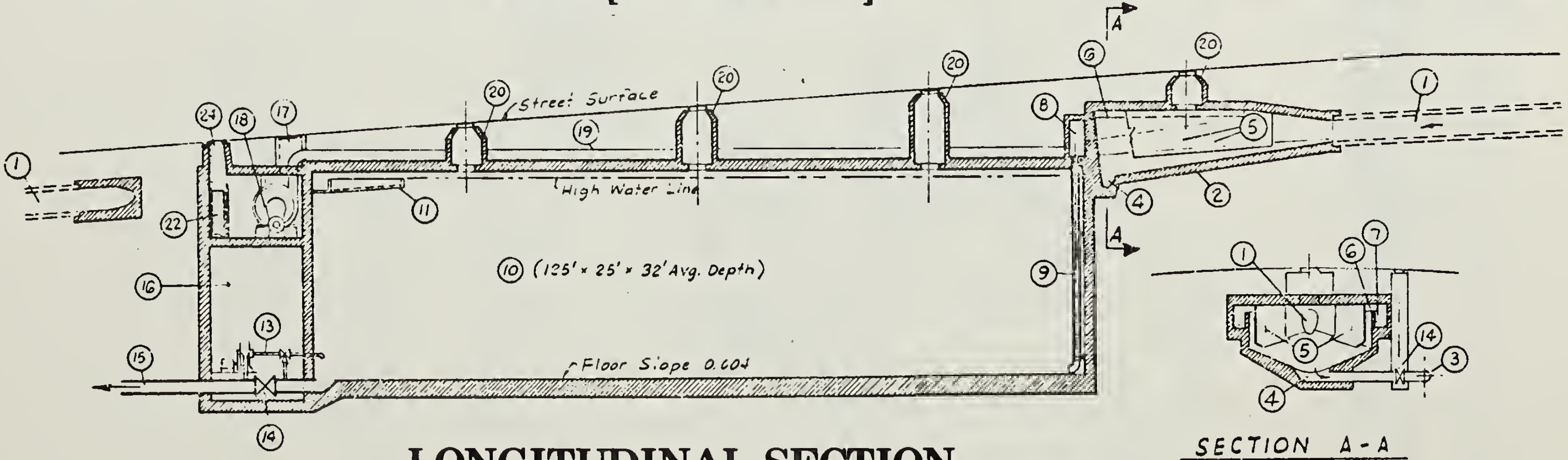

SAN FRANCISCO BAY
UPSTREAM BASIN REMOTE FROM TRANSPORT LINE RETURNS ALL FLOWS TO SEWER
P
OVERFLOW
TRUNK SEWER
SHORELINE BASIN
UPSTREAM BASIN CLOSE TO TRANSPORT LINE WITH DIRECT CONNECTION. ONLY BASIN OVERFLOWS CONTINUE TO SHORELINE BASIN.
PACIFIC OCEAN
WESTSIDE TUNNEL
TUNNEL STORAGE
TRANSPORT SYSTEM
OCEAN OUTFALL
CROSSTOWN TUNNEL
LAKE MERCED WET WEATHER TREATMENT PLANT

CONCEPTUAL DESIGN OF UPSTREAM RETENTION BASIN

Figure VI-8



PLAN [roof removed]



LONGITUDINAL SECTION

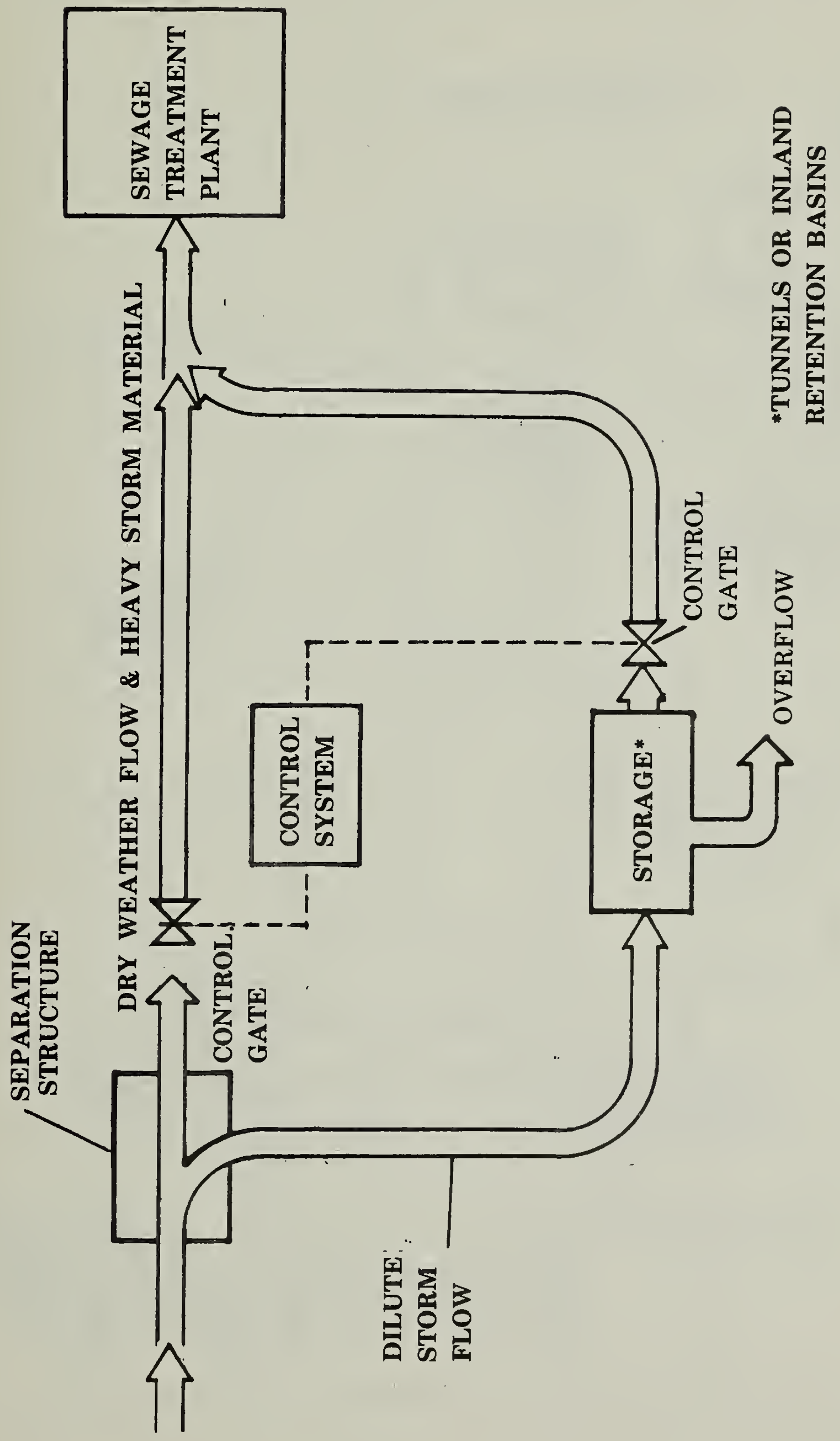
SECTION A-A

KEY

1. Existing combined sewer (2'-6"x3'-9")
2. Material separation structure.
3. Dry weather sanitary & optional storm flow bypass
4. Drain to bypass-shunts heavy & floatable fractions past storage.
5. Baffles-entraps floatables until after storm.
6. Weir-retains heavy material, passes dilute storm flow to storage.
7. Influent to storage
8. Distribution channel
9. Downcomers
10. Storage compartment (100,000 cu.ft.)
11. Overflow trough
12. Overflow discharge conduit
13. Emergency dewatering pump system
14. Control gate
15. Gravity discharge-reconnects with combined sewer downstream.
16. Underground service area
17. Air intake
18. Fan
19. Forced air conduit
20. H.P. washdown system vault
22. Local automatic & remote control station- controls valves, pumps, ect. receives signals from central control station
24. Station access manhole

Reference 2-Plate VI-10

Figure VI-9

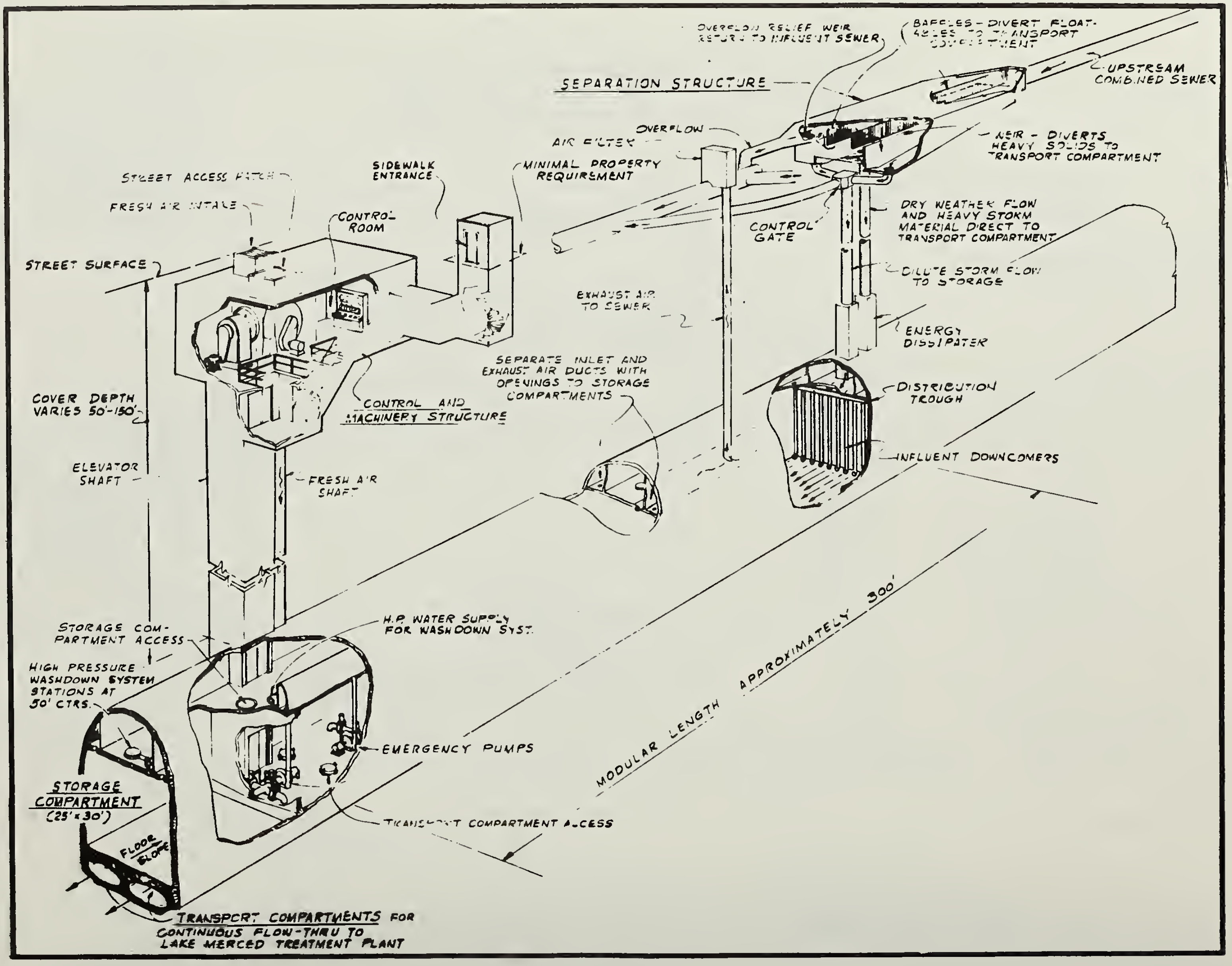


SCHEMATIC DIAGRAM OF WET WEATHER CONTROL

Reference 2-Plate VI-9

Figure VI-10

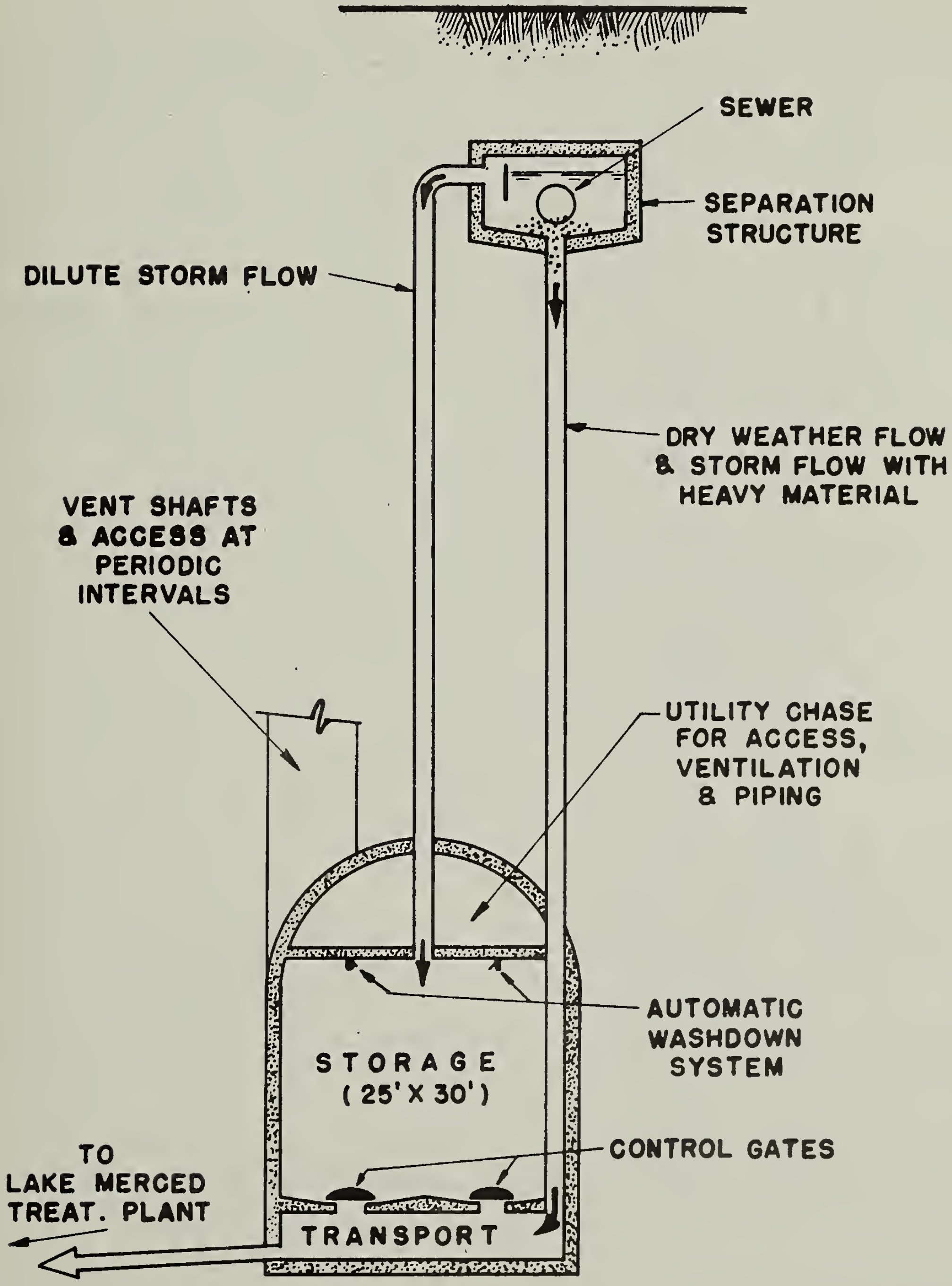
TUNNEL PERSPECTIVE


OVERFLOW RELIEF WEIR RETURN TO INFLUENT SEWER
BAFFLES - DIVERT FLOATABLES TO TRANSPORT COMPARTMENT
UPSTREAM COMBINED SEWER
SEPARATION STRUCTURE
OVERFLOW
AIR FILTER
WEIR - DIVERTS HEAVY SOLIDS TO TRANSPORT COMPARTMENT
MINIMAL PROPERTY REQUIREMENT
SIDEWALK ENTRANCE
STREET ACCESS HATCH
FRESH AIR INTAKE
CONTROL ROOM
STREET SURFACE
CONTROL GATE
DRY WEATHER FLOW AND HEAVY STORM MATERIAL DIRECT TO TRANSPORT COMPARTMENT
DILUTE STORM FLOW TO STORAGE
EXHAUST AIR TO SEWER
ENERGY DISSIPATER
SEPARATE INLET AND EXHAUST AIR DUCTS WITH OPENINGS TO STORAGE COMPARTMENTS
DISTRIBUTION TROUGH
COVER DEPTH VARIES 50'-150'
CONTROL AND MACHINERY STRUCTURE
INFLUENT DOWNCOMERS
ELEVATOR SHAFT
FRESH AIR SHAFT
STORAGE COMPARTMENT ACCESS
H.P. WATER SUPPLY FOR WASHDOWN SYST.
HIGH PRESSURE WASHDOWN SYSTEM STATIONS AT 50' CTRS.
MODULAR LENGTH APPROXIMATELY 300'
EMERGENCY PUMPS
STORAGE COMPARTMENT (25' x 30')
FLOOR SLOPE
TRANSPORT COMPARTMENT ACCESS
TRANSPORT COMPARTMENTS FOR CONTINUOUS FLOW-THRU TO LAKE MERCED TREATMENT PLANT

Reference 2-Plate VI-7

Figure VI-11

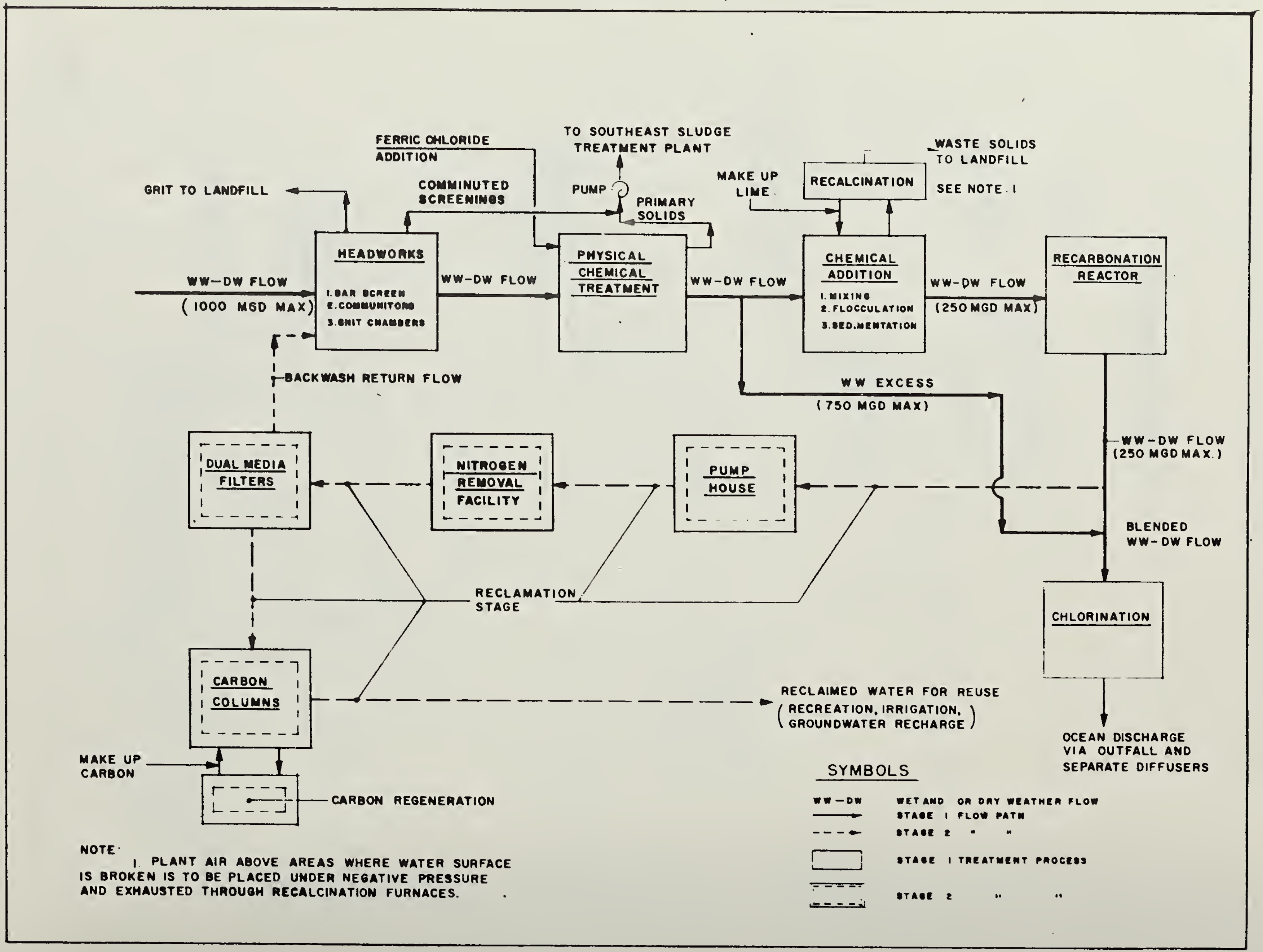
SCHEMATIC SECTION OF TUNNEL


SEWER
SEPARATION STRUCTURE
DILUTE STORM FLOW
DRY WEATHER FLOW & STORM FLOW WITH HEAVY MATERIAL
VENT SHAFTS & ACCESS AT PERIODIC INTERVALS
UTILITY CHASE FOR ACCESS, VENTILATION & PIPING
AUTOMATIC WASHDOWN SYSTEM
STORAGE (25' X 30')
CONTROL GATES
TO LAKE MERCED TREAT. PLANT
TRANSPORT

Reference 2-Plate VI-8

Figure VI-12

PROPOSED SOUTHWEST WATER POLLUTION CONTROL PLANT CONCEPTUAL FLOW DIAGRAM



Reference 2-Plate VI-20

Chapter VII

CONTINUING STUDIES

In seeking the most efficient and effective system for controlling San Francisco's wastewaters, a large amount of data has been gathered and analyzed and relatively unknown control methods considered. Following development of the general control plan, information necessary to optimize design and assure proper operation of the system is being gathered. Studies are necessary and are planned to gather further information about wastewater treatment and effluent quality, design and operation of upstream retention basins, and the feasibility of automatic control with the proposed central management software-hardware system.

The scope of the studies are presented in the following documents:

- "Detailed Scope for Sewage Treatment Pilot Plant In Situ Study."
- "Application for Research, Development, and Demonstration Grant/Upstream Retention — A Demonstration for Storm and Combined Sewer Overflow Control," March 10, 1972.
- Memorandum dated July 5, 1972, from M. B. McPherson to William R. Giessner.
- M. B. McPherson, City and County of San Francisco Plan for Research, Development and Demonstration Period-of-Wet-Weather Upstream Control Program, June, 1972, "An Outsider's Interpretation." Draft

PILOT TREATMENT PLANT STUDY

The study scope evaluated in this report is an initial scope subject to change during and following selection of a consultant to complete the work. It is highly probable that many of the recommendations made with respect to this work scope will not apply to the final document.

This study encompasses more than a pilot plant study of treatment processes. The study includes monitoring of wastewater quality at the existing treatment plants to substantiate and expand data collected in a previous study and in the course of normal wastewater quality monitoring at the treatment plants. The constituent concentrations produced by various treatment processes will be evaluated to determine the relationship with the Water Quality Control Plan for Ocean Waters of California and an anticipated similar plan for bays. From a review of the corrected data, constituents will be grouped in the following categories: (1) no treatment is required for removal, (2) industrial wastes are the main contributor, (3) residential wastes are the main contributor, (4) control is attainable by changing water supply, and (5) undetermined source.

The data are to be analyzed with respect to the effect of the City's industrial waste control program. Constituents which can be best controlled at the source are to be identified. For constituents which may cause violation of requirements, an estimated cost allocation to the discharger is to be developed. In addition, existing industrial waste quality data are to be reviewed and additional data gathered as required.

The pilot plant portion of the study will consist of at least one month of operation for each process tested. The following information will be developed: (1) compliance of effluent with the State Water Resources Control Board's Ocean Plan and anticipated similar plans for bays and estuaries, (2) process reliability information for selected constituents, (3) design loading rates, and (4) estimated capital, operation, and maintenance costs.

Treatment Processes

The following processes are to be tested: (1) primary sedimentation with addition of low-dose ferric chloride and polymer (saltwater addition if necessary), (2) primary sedimentation with addition of high-dose ferric chloride and polymer (saltwater addition if necessary), (3) Process 1 followed by high-dose lime addition and secondary sedimentation, (4) Process 1 followed by dual-media filtration, (5) Process 2 followed by dual-media filtration, (6) Process 3 followed by ammonia stripping and recarbonation, (7) Process 3 followed by recarbonation and super-chlorination for ammonia removal, (8) Process 7 followed by dual-media filtration, and (9) Process 8 followed by carbon adsorption.

A biological process which will replace any of the above processes or combinations without reducing performance or increasing costs is to be presented for consideration.

Following acquisition and analysis of the above data a preliminary plant layout and equipment list are to be prepared for a selected process and an alternate.

Wet Weather Treatment

The proposed study does not consider treatment of combined sanitary sewage and storm runoff. The information being gathered is directed entirely toward treatment of dry weather flows. This emphasis is inconsistent with implementation of the Master Plan since operational data would not be provided for design or operation of the proposed 1,000 mgd split-flow wet weather treatment plant. The great variations in flow rate and influent quality during these periods require that operational data be gathered for at least the proposed Level 1 (primary sedimentation with low-dose chemical addition) wet weather treatment process.

Questions remain unanswered concerning the feasibility of operating a treatment plant for a small fraction of the year, and when in operation whether the process will perform as anticipated under the highly variable flow and quality conditions. Operational data should be gathered to assure that the goals of the Master Plan are attainable with the proposed process.

Operational data gathered at the existing treatment plants since completion of chemical addition facilities is of some use to determine performance under varying quality and to some extent varying quantity during storm runoff conditions. This information, however, gives no insight into problems associated with the on-off operational situation or the extreme flow variations which are expected at the wet weather portion of the proposed plant. Pre-design studies of the wet weather treatment process are probably more critical, although no more necessary, than dry weather treatment studies because of the greater availability of operational data for treatment of dry weather flows.

The pilot plant studies do not consider biological secondary processes in as objective a manner as chemical processes. Although it is likely that biological secondary systems would not operate efficiently due to high influent quality variation, this alternative should be evaluated and compared with other processes on the same basis.

Data Presentation

A minor shortcoming of the proposed study scope is the required method of data presentation. The use of plots with data frequency distribution and waste discharge requirements shown is an excellent means of data presentation. However, care must be taken to assure that the distribution and requirements are comparable. For example, the State Water Resources Control Board's Ocean Plan places limits on the 50-percentile and 90-percentile values for the distribution for any consecutive 30-day period. Comparison of these values with a distribution for any period other than 30 days may have limited relevance. Consideration must be given also to the manner in which the waste discharge requirements are stated. For a given quality parameter a requirement may limit the minimum, mean, median, maximum, a percentile, or a combination for sampling periods which vary between requirements. If the mean value of the distribution is also shown on the plot, a requirement in any of the forms can be easily compared with a distribution for the appropriate sampling period.

The study scope emphasizes the use of the "coefficient of reliability" as a means of evaluating and comparing process performance. The coefficient is defined as follows:

> "The 'Coefficient of reliability' (Cr) is an arbitrary number which has the limits of $-\infty°$ to $\infty°$ which defines the range and displacement in which 80% of experimental data will fall.
>
> "$Cr = \frac{1}{R} \bullet d$
>
> Where:
>
> R = Range of quantitative values which fall between 10% and 90% probability for any constituent and any loading rate.
>
> d = Displacement between and desired (requirement) value and the nearest experimental value to be considered."

The definition of "d" is not clear. "d" should be the displacement between the required mean and the measured mean, the required 80 percentile and the measured 80%, or whatever is applicable.

In addition, the validity of the "coefficient of reliability" itself is doubtful. While both "d" and "R" would be very helpful parameters in selecting the best process to meet needs, there is no reason to believe that their ratio is a parameter which will determine the preferable treatment process. Specifically, given two processes and a requirement, because the ratio of the displacement of the distribution from the required concentration and the distribution range are equal, does not necessarily mean that the two processes are equally reliable or desirable from either a compliance or a performance standpoint.

Recommendations

The City is aware of the problems raised in this discussion and is developing a detailed work plan for the study which changes the methodology and scope of work substantially. This work plan is not available for review at this time. General recommendations with regard to the study as outlined in Detailed Scope for Sewage Pilot Plant In Situ Study, as initially presented are as follows:

- Biological secondary processes including conventional activated sludge and pure oxygen should be evaluated for the secondary portion of the plant.
- Existing data on ferric chloride addition and ferric chloride plus polymers addition to primary should be reviewed to determine adequacy for evaluation of these processes.
- Consideration should be given to alum addition as an alternative primary and secondary treatment process.
- Low-dose lime treatment should be evaluated as an alternative primary treatment process.
- Chlorine-demand and chlorination feed-rate to achieve alternative levels of disinfection should be evaluated for each process.
- Dechlorination methodology should be evaluated.
- Process steps 3 (ammonia stripping) and 3A (ammonia removal) are not applicable for discharge to the ocean but may be applicable, although not likely, at some later date for discharge to San Francisco Bay. It therefore is not necessary to proceed with these studies at this time. Process steps 4 and 5 therefore can also be deleted.
- Maximum use should be made of existing treatment facilities to determine effectiveness of alternative chemicals.
- Operation of processes to treat wet weather flows in the on-off mode expected at the wet weather treatment plant should be included in the study. Early conversion of the North Point plant to a wet weather facility will offer an excellent opportunity to gain practical operational experience.
- It may be possible to decrease sampling and analysis frequency for various parameters as statistically sound data become available. The consultant should limit sampling to that needed to provide statistically reliable data and the contract should permit that flexibility.

The suggested processes listed herein, the recommendation to review existing data, and the possible use of existing facilities for study are very general and based upon a review of the scope of the study as outlined at the time of preparation of the contract. It is recommended that the contract contain a task requiring the consultant to prepare a pilot plant work plan including a listing of all processes worthy of evaluation and a suggested method of proceeding with the evaluation of each process. Such an approach will assure that adequate consideration is given to the study scope.

PILOT RETENTION BASIN PROJECT

In March 1972 the City submitted an application to the Environmental Protection Agency for a $3.14 million Federal demonstration grant project (City's share of financing, 25 percent). The objective of the project would be to demonstrate the feasibility and effectiveness of historical-based event prediction, solid/liquid pre-separation, and upstream retention facilities, to effect the control and management of combined sewage overflows. The project would:

- Construct and operate a prototype upstream retention basin.
- Evaluate basin effectiveness and design by hydraulic and mathematical modeling.
- Evaluate pre-separation devices.
- Further the development and testing of the data base for storm behavior prediction and basin storage control logic.
- Summarize findings and conclusions to guide future basin design and construction.

This essential and evolutionary project has not yet been approved for funding. Included in the project is the purchase of additional computer hardware necessary to perform the assessment and control functions and to increase data-handling capabilities.

From the construction and operation of the prototype, it should be possible to obtain:

- A better idea of costs.
- First-hand experience in maintenance and cleaning required.
- Data on effectiveness as a treatment basin, or diversion of solids and floatables around the storage compartment depending on the design concept adopted.
- Data for design of an outlet control system.
- Information on odors produced in the basin during and following rains and during the summer dry season.

The last item will help to determine the type of ventilation system required. It may be undesirable to exhaust air from the basin by large fans to the sewer as proposed. This could cause foul air to be discharged at various locations along the interceptor. With the basin filling and the interceptor full the fan would not deliver. It is suggested that consideration be given to using gravity vents to the atmosphere with forced air ventilation and air scrubbing if found necessary. A supply fan and built-in concrete ducts for operation when men enter the chamber for cleaning should also be considered. The ventilation system should be thoroughly tested as part of the model program.

By proper selection of the installation site, direct pollution abatement benefits and flooding relief may be realized.

CONTROL SYSTEM AND CENTRAL MANAGEMENT PLAN

Colorado State University is assisting in a control and modeling project to evaluate the potential and effectiveness of automatic control of the storage and transport facilities of the Master Plan.

Storm Behavior

The ASCE Urban Water Resources Research Program in its Technical Memorandum No. 15* defines the need for automated surveillance and control in the following excerpt from Treatment of Overflows:

> Because combined sewer overflows occur over a very small part of a year, any facilities provided for treatment of potential overflows must be put on the line almost instantaneously. This means that not only would such plants be idle more than around nine-tenths of the year, but that they would have to be activated immediately with the occurrence of any stormwater flow that would exceed interceptor sewer capacity. Effectiveness of overflow pollution abatement using treatment facilities designed specifically for that purpose therefore will require some form of automatic operational control. Remote supervisory control would quite likely not be adequately responsive. The control logic required has yet to be developed, and it is possible that different metropolitan sewer systems will require their own fairly unique logic development.

In the case of San Francisco, the above description is more appropriate to the operation of the proposed 32-46 retention basins and the 11-12 tunnel storage elements, each of which will be capable of variable feed and withdrawal rates. The objective of the control system will be to optimize the containment and treatment of storm runoff with actions dependent upon the storm pattern, treatment, and storage availability, and projected storm and system behavior. When overflows to receiving waters are necessary, system controls will permit the releases to occur in the least damaging manner.

Although the currently envisioned automatic control system is a highly sophisticated central computer operated system, such complex facilities may not be necessary. An important aspect of any control system study should be to evaluate and compare less complex automatic controls ranging from computer aided supervisory control to completely local control at individual units responding directly to local hydraulic flow and retention basin head.

For the proposed control system, the most difficult task is the real time prediction of storm behavior. Has the peak intensity passed? Will the storm cell move progressively from area A to B to C or by some other route? Will it increase or decrease in intensity with movement? Is a second cell developing? Has the storm stalled severely stressing a limited area? These are but a few of the questions to be studied in executing a control logic (i.e., if we know what the storm is going to do next, then we can implement the most effective counter-measures). Likewise, if an initial prediction proves to be false, can it be detected and corrected before the problem is compounded? Obviously, the success of such a program will be largely dependent on a nearly instantaneous monitoring and data scan capability and a carefully compiled, catalogued, and interpreted body of extensive historical data.

Even with the best of systems, it must be anticipated that the storm behavior prediction will only be partially successful (one need only to recall the difficulties of hurricane tracking and prediction); however, as the library of historical data grows performance should improve. In order to collect, file, and access the data, computer usage is essential.

It is proposed to install a pilot retention basin for study of design and operation throughout a minimum of one entire rainy season following complete tune-up and testing. These questions should be answered in the proposed study. Consideration should be given to constructing the retention basin in an area that is presently being affected by waste overflows. This will permit study while improving conditions.

The San Francisco System

On September 1, 1970, the City of San Francisco awarded a $420,000 contract to Control System Industries, Santa Clara, California, for a hydrologic and hydraulic data acquisition and recording system. This contract resulted in a system involving 30 remote recording rain gages and 113 (since increased to 120) sewage flow level monitors all reporting to a Honeywell H-316 mini-computer

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* Ref. 29-P.80

(16,384 word core memory) with teletype printout and magnetic tape recording (2 tape drives) capabilities. The remote signals are transmitted over leased telephone lines to the computer located in the Department of Public Works, Bureau of Engineering offices, at 15-second intervals. All data is recorded in chronological or time-ordered sequence for future use on magnetic tape and selected data is printed out for system performance evaluation and engineering analyses. The system first became operational in March 1971. The data are transferred selectively to a larger computer system for sorting and analyses (i.e., the identification of the maximum 5 minute, 10 minute, 15 minute, etc., rainfall accumulations by gage) and for the production of SYMAP displays. The SYMAP's graphically show simultaneous storm intensities, accumulations in discrete intervals, and the movement of storm cells across the City. They may be printed on the basis of any repetitive time period.

The flow depth monitoring within the sewer system is to be used to develop time varying runoff coefficients, times of concentration, and fluid flow behavior for each identifiable storm pattern, drainage basin, and antecedent condition.

From the above, repeated over a great number of storms and continuously updated, it is intended that a series of historical response functions be prepared. Finally, based on the historical response records, a series of predictive functions will be developed as a control decision base.

Control Devices — Control will be exerted on the San Francisco system by regulating the withdrawal rates from the basins. The preliminary sizing of the retention basins indicates that they will have a nominal storage capacity of 0.10 inches of runoff (Alternate A) to 0.64 inches of runoff (Alternate D). These correspond to 0.16 inches of rainfall in Alternate A to 0.99 inches of rainfall in Alternate D. There are on the average (based on Federal Office Building gage) 381 hours of rainfall per year, 27 hours of which exceed 0.16 inches of rainfall (i.e., would fill the basins in less than 1 hour if uncontrolled and no withdrawal). A 1-hour rainfall accumulation of 0.99 inches will occur less frequently than an average of once in 25 years. The preliminary withdrawal rates from each basin will be capable of being adjusted to the runoff equivalent of between 0.0 and 0.30 inches per hour of rainfall. The 0.30 inches per hour rainfall rate for an hour's duration is exceeded on the average in only 5 hours per year.

The above figures are presented to set the facility sizes and capacities in real world perspective. It is recognized that over shorter time frames rainfall intensities could be considerably greater and that the one-hour time interval is merely a convenient but arbitrary time interval. Also, the use of the Federal Building gage as representative of average citywide rainfall, while the best available data at the time of the report, is questionable in light of the new data being collected. The figures do indicate the high importance and potential of control in implementing Alternate A is progressively reduced as greater and greater storage volumes are provided.

For example, on the average less than two storms per year would exceed the storage capacity offered by Alternate D with diversion to treatment limited to the existing interceptor capacity.

The actual control devices would be motor operated gates upstream of the basins to control the rate of inflow and bypass and motor operated gates or pumps controlling the basin dewatering rates. The sum of the dewatering rates from all basins at any instant, corrected for transit times and in transit storage, would equal the storm flow treatment rate. Limit switches and level recorders would transmit via leased telephone lines instantaneous status data to the central management console to identify basin performance.

Control Logic — The control logic will be developed over three phases: development, prediction, and real time control. Using mass balance techniques, and taking variability of the rainfall into account, rainfall and runoff data will be sorted and classified until a significant number of similar experiences can be grouped for consistency and uniformity of response. If a degree of consistency can be attained thus permitting storm runoff behavior prediction, then a problem identification matrix will be developed. This matrix will initiate real time corrective procedures in response to the identified storm pattern.

The remote monitoring of the system will permit continuous comparison of real time status versus predicted status and corrected system updates where necessary. Experience alone will set the limits at which actions are initiated, otherwise a condition of over-control could easily develop. The goal throughout is the maximum containment and treatment of runoff before overflows are allowed, and when overflows cannot be avoided to permit selection of the overflow location(s).

Implementation Plan

A 5-year program has been targeted for the development and testing of the control system concepts and hardware: running approximately from June 1972 to June 1977. The program is already underway with the rainfall runoff data collection and analysis now in its second year. In addition to the major effort being expended by the City with staff personnel, three contributary projects are of special significance: the Colorado State assisted studies, the Pilot Retention Basin project, and the ASCE Urban Water Resources Research Program assistance.

Colorado State University Project — Under a research grant from the Office of Water Resources Research CSU is developing control logic for automation of combined sewer systems for overflow abatement. Within this study, CSU has pledged a minimum of 6 months effort for assistance in the San Francisco Plan. The City has agreed and is supplying CSU with relevant available data for one catchment area, Vicente Street. The physical components, control-actuation devices, storm inputs (approximately 12 storms total), and flow routing are being simulated on a computer. A matrix of control criteria is to be investigated and control logic for the most feasible developed. Responses to system malfunctions and erroneous signals will be considered. The study is to be complete by mid-1973.

Pilot Retention Basin Project — The objectives and scope of this project were discussed in the previous section. Of particular benefit to the Central Management Plan will be the expansion and real time testing of the data base and control logic. Delays in undertaking the project will significantly set back the implementation plan schedule.

ASCE Urban Water Resources Research Program Assistance — ASCE, under its contract with the Office of Water Resources Research to "facilitate research on rainfall runoff quality of sewered urban catchments," has pledged a minimum of 2 man-months of effort to the project. This provides a broadly researched and highly professional input to the project and effects the liaison between the City and CSU project personnel.

Comparisons with Other Cities — No city has yet demonstrated a program of automated real-time control of wet weather flow management. The two most advanced systems reviewed are those at Seattle and Minneapolis-St. Paul. The Seattle system has been operated under remote supervisory control (system status displayed at a central control facility where decisions are made by an observer and controls implemented) since April 1972. The first attempts at hands-off computer control will be made this spring, 6 years after the project initiation. The Minneapolis-St. Paul system similarly has been operated under supervisory control since April 1969 with the intent of eventual fully automated control. A mathematical model of the interceptor system has been developed and is used for the supervisors' guidance, but the additional step of automated decision-making has not been fully implemented.

CONCLUSIONS

The continuing studies for refinement of the Master Plan have been carefully engineered and initiated. They are not limited to those discussed in this chapter, but include detailed oceanographic studies, bioassays, rainfall analysis, as well as further analyses of potential Plan refinements. The program foresees the potential problem areas and is selectively ordered in stepwise fashion, allowing intermediate reviews, assessment, and redirection where necessary. The program is staged with progressively increased capital investment backed by progressively improved confidence in goal attainment. The time period allocated is the best that can be expected, based on the experience of other cities. The broad base of advisors and participants increases the project's professional merit and enhances the prospects of success.

Finally, the program is one of skilled evaluation building upon itself professionally into areas at the frontier of wet weather waste control technology. The total wet weather program cost differential between Alternate A and Alternate D is over $300 million. If a higher level of overflow abatement can be attained using less structural investment balanced by greater control, the cost savings should be appreciable. The studies underway and proposed by the City are necessary regardless of changes made in the Master Plan. They will provide data to permit refinement of specific elements and alternatives through evaluation with actual measured conditions and responses. The approach is totally endorsed.

Chapter VIII

COMPARISON OF MASTER PLAN WITH PLANS OF SIMILAR COMMUNITIES

Seventy-six of the nation's largest cities have combined wastewater discharge systems which serve a total population of 20 million, or approximately 10 percent of the citizens of the United States.

This chapter compares the plan as presented in the Master Plan Report with plans developed for control of wet weather flows for Chicago, Boston, Seattle, Minneapolis-St. Paul, New York City, and Washington, D.C. Comparisons are based upon plan elements, cost, and study conclusions and recommendations.

Recognition and concern of the pollution potential of combined sewage overflows and stormwater discharges is largely limited to the last decade. While several large cities embarked on long-range sewer separation programs in the 1950's and earlier, these programs in light of water quality objectives are now subject to question and reevaluation.

The enormity and complexity of urban runoff management are such that in-depth analyses, such as those undertaken by the City of San Francisco, have few peers with which to make comparison. One notable exception, the City and Metropolitan Areas of Chicago, is measured in detail against the Master Plan. Other cities and metropolitan areas have contributed, frequently with Environmental Protection Agency assistance, limited objective demonstration projects which explore alternative, and sometimes innovative, control schemes upon which to build master plan programs.

A preevaluation consideration is the rapidly changing and increasing regulatory and public constraints on pollution and environmental objectives which tend to change ground-rule engineering assumptions so frequently that plans of a few years ago may be grossly outdated today or tomorrow.

The steep topography and highly developed character of the City result in quick concentration and high peaks of storm flow during rainstorms which result in overflow of combined sewage to the Bay and ocean through 41 bypass structures.

Since the greater part of the City lies above elevation 50, the potential exists for intercepting a major portion of the dry weather flow and a significant amount of storm flow and conveying it by gravity to a common point for treatment. The Master Plan Report recognizes this by proposing a high level west side intercepting sewer and a crosstown tunnel for storage of stormwater and transport of wet and dry weather flow to a treatment plant adjacent to Lake Merced. A major portion of the storm flow tributary to the west side interceptor would be controlled by upstream retention basins with gravity flow to the interceptor.

The character of the existing drainage system and the location of the 41 outlets have a profound effect on the control of wet weather flows since the whole object is to contain and treat wet weather flows thus eliminating overflows to the greatest extent economically feasible.

Elements of the San Francisco Master Plan noteworthy of comparison to planning in other cities or metropolitan areas are:

- The relative wet weather treatment capacity of 8 times dry weather flow or the equivalent of treating the entire runoff from a one-year storm in 15 hours. (At a 0.1 in/hr treatment rate.) This capacity is equal to or has been exceeded 62 times in 62 years of record.
- The total storage capacity provided of 8.4 percent (Alternate A) to 53.7 percent (Alternate D) of the runoff from a one-year storm.
- The combination of storage and treatment to limit the average number of overflows to 8 per year (Alternate A) to 1 in 5 years (Alternate D).
- The highly sophisticated control and monitoring system — the average storm duration is only 3 hours and during this time the City's largest treatment facility must be brought into highly effective service and, since used jointly for dry weather flows, increased in its effective treatment rate by several times. Up to 17 pumping stations must be started and a multitude of decisions made as to whether to store, drain, or bypass at each of the available storage facilities. The 3 hours average duration is based upon Master Plan Report Storm event definition in which a storm is considered over

when 1 hour passes without rainfall. Thus 2 or more "storms" may occur in a single day, which is frequently the case, and may be so closely spaced as to permit the treatment plant to operate continuously until the series of storms is passed.

- Total project costs of $433 million ($18,090 per acre, 0.1 in/hr withdrawal rate, Alternate A storage and primary level treatment) to $930 million ($38,790 per acre, 0.3 in/hr withdrawal rate, Alternate D storage, and tertiary level treatment. Costs updated from those presented in Master Plan Report). These estimates include the capital costs of dry weather as well as wet weather solutions projected to 1974 prices.
- A construction program staged over 20-30 years.

Table VIII-1 compares the basic elements of the San Francisco plan with presently available data from other cities. To the extent that data are available, the costs have been adjusted to a base equal to that used for San Francisco using ENR Construction Cost Indexes.

Records show that rainfall in San Francisco is much lighter than in cities on the east coast and in the midwest, the 5-year intensity for periods of 30 and 60 minutes being roughly half as great. Records also show that considerable rain may fall, soaking the ground thoroughly, before the maximum 30-minute intensity occurs, in contrast to the east and midwest where the critical storms are frequently of the thunderstorm type with the maximum intensity of rain occurring soon after its beginning.

The steep topography and high degree of imperviousness of the sewered areas result in rapid runoff and high peak flows.

The various study conclusions and recommendations are summarized for comparison in Tables VIII-2 and VIII-3 respectively. Storms in the midwest and eastern United States are considerably more intense and of greater volume than the average San Francisco storms. Seattle experiences a greater annual rainfall than San Francisco but the average storm intensities are considerably less. These relationships are important in determining the cost effective balance between storage and treatment with minimum storage associated with minimum intensity variation.

CHICAGO, ILLINOIS

The details of this plan are found in "Development of a Flood and Pollution Control Plan for the Chicagoland Area — Summary of Technical Reports" dated August 1972. This plan supersedes the May 1970 deep-tunnel plan developed for the Chicago area. The system study was sponsored by the Metropolitan Sanitary District of Greater Chicago, the Institute for Environmental Quality, State of Illinois, and the Department of Public Works, City of Chicago.

The major objectives of the Chicago program are to prevent backflow to Lake Michigan, a source of potable water and high recreational use, for all storms of record, and to meet the applicable waterway standards which prescribe tertiary treatment under dry weather flow conditions and a high degree of treatment for all discharges.

The recommendations of the Chicago report are:

- To treat all wet weather flows at a dry weather flow facility sized for 1.5 average dry weather flow maximum rate.
- To intercept all existing wet weather outfalls by a conveyance tunnel system.
- To store all intercepted flows above treatment capacity at one large and two auxiliary open-pit reservoirs in areas with restricted public access until absorbed by the dry weather flow treatment facilities operating at nearly a constant maximum rate. This type of facility would not appear feasible for San Francisco because of the high land and buffer requirements. The major reservoir would be aerated continuously and accumulated solids removed periodically by dredging. Most storms, up to 1.0 inch total runoff averaged over the entire service area, would be dewatered in 2 to 10 days and the largest in 50 days.

The total storage provided is equivalent to 3.14 inches of runoff or 9 percent of the annual average rainfall. The frequency of overflows is estimated to be 4 times in 21 years with a wet weather flow treatment rate of 650 mgd.

The estimated total project cost with tertiary treatment for an area 10 times the size of San Francisco is $12,543 per acre in 1974 dollars. An implementation plan staged over 10 years is recommended.

The comparatively low unit cost is largely a result of the massive open excavation used to develop storage capacity and the large total area involved. The estimated cost per gallon storage provided is $0.28 as compared to $1.10 per gallon in San Francisco Master Plan Alternate D.

BOSTON, MASSACHUSETTS

This plan presented in "Improvements to the Boston Main Drainage System" prepared by Camp, Dresser & McKee for the City of Boston, September 1967, is based largely on preliminary Chicago deep tunnel studies. The four alternates studied include complete separation, chlorine detention tanks, surface holding tanks, and deep tunnels.

The system consists of 12,000 acres of combined sewered area, which is half the size of San Francisco, plus a 10,000 acre area whose sanitary sewers are connected to the system.

The design objective is to completely capture the 15-year frequency, 24-hour duration storm assuming 90 percent runoff. This is provided by a storage capacity of 1.84 inches of runoff in conjunction with facilities for continuous pumping to the ocean at rates up to 3,300 mgd. The outfall diffusers are located 5.5 miles from the nearest land area. The only treatment planned is chlorination, at 30 mg/1 feed rate and 90-minute minimum retention time, with deep water ocean discharge with minimum dilution ratios of 200:1. A maximum of two days is allowed for dewatering the tunnels.

Costs associated with the project are estimated, after adjustment to 1974 San Francisco costs, as varying from $65,000 per acre for the described deep tunnel plan to $83,000 per acre for complete separation.

In addition to this study, Cambridge, Massachusetts, has constructed an Environmental Protection Agency demonstration facility for retention and chlorination of combined sewer overflows at Boston University Bridge which was placed in service in 1972. The Greater Boston Area has recently undertaken a comprehensive master plan study for the combined City and metropolitan areas.

SEATTLE, WASHINGTON

Combined sewer overflow abatement activities in the Seattle area are described in the Environmental Protection Agency report, "Maximizing Storage in Combined Sewer Systems," prepared by the Municipality of Metropolitan Seattle, December 1971. The project objectives are:

- Continuous monitoring of water depths in sewers and other factors needed to compute flows and capacities in sewers and treatment works.
- To receive and process meterological data and predict runoff intensity and volume on the basis of historical records.
- To reduce flow and store waste in portions of the pipeline system to permit increased interception from areas experiencing high runoff rates.
- To control locations of overflows thereby minimizing their harmful effects on the receiving waters. The program, operational in late 1971, was based on the expectation that separation projects, together with computerized storage control, would eliminate or reduce overflows to a level that would permit receiving water quality standards to be met.

Highest priority is given to abating summer storm pollution. A one-year frequency summer storm having a peak runoff rate of 30 to 60 times dry weather flow is the basis for design. Interception capacity is generally 3 times the estimated future dry weather flow which will provide excess capacity for many years. The optimal utilization of this excess capacity, both for storage and accelerated interception and transport to treatment, is the key to the control system.

The estimated maximum safe storage in the trunk line and interceptors is given as 31.8 mg. After the initial partial separation, which will result in separation of approximately 18,000 acres of a total 36,000 acres of combined sewered area and result in a 70 percent reduction of flows in the combined system, the safe storage will be roughly equivalent to 0.05 inches of runoff from the combined and partially separated area. This compares to 0.10 inches of runoff stored in San Francisco Alternate A. The intercepted flows are presently given primary treatment before discharge to Puget Sound at the West Point treatment facility. No special wet weather treatment facility is contemplated.

The effectiveness of the system is dependent on a highly sophisticated control and monitoring network. Population growth in the Seattle area is increasing and progressively reducing the available safe storage within the interceptors thus, over a period of years, offsetting improvements in system management.

The estimated costs associated with partial and complete separation based on 1958 conditions range between $5,000 and $10,000 per acre, respectively. The effectiveness of partial separation coupled with in-system storage is estimated as reducing by 30 to 50 percent the release of contaminants to the receiving waters. In the case of Lake Washington a further reduction up to 50 to 60 percent total is anticipated by redirecting 75 percent of the new storm drainage out of the basin.

MINNEAPOLIS-ST. PAUL, MINNESOTA

This system, similar in many respects to Seattle's, is described in the report for the Environmental Protection Agency by the Minneapolis-St. Paul District, now the Metropolitan Sewer Board, entitled "Dispatching System for Control of Combined Sewer Losses," March 1971, and in a January 1970 article in the Journal of the Hydraulics Division, Proceedings of the American

Society of Civil Engineers, entitled "Real-Time Computor Control of Urban Runoff" by James J. Anderson.

A total sewered area of 144,000 acres, of which 31,900 acres or 22 percent are combined, is tributary to a single regional wastewater treatment plant. The estimated connected population is 1.4 million persons and the 1969 average treated flow was 230 mgd with a peak dry weather flow of 300-350 mgd. The interceptors, constructed in the 1930's, were sized to carry the runoff resulting from a rainfall intensity of 0.04 inches per hour. The last interceptor to the treatment works has a design capacity of 620 mgd or approximately 2.7 times the average dry weather flow from the total service area.

A sewer separation program, which is limited to street drainage and does not include building drainage, has been underway since 1933 and is continuing. Separately sewered suburban area sewage flows pass through common interceptors with the combined flows en route to the treatment plant. Prior to project implementation, it was estimated that up to 6 percent of the annual dry weather flow was lost to the river system through storm overflows at some 150 locations.

The Minneapolis-St. Paul program, supported 50 percent by a 1966 Environmental Protection Agency grant, has the following major objectives:

- To reduce overflow occurrences, duration, and volume.
- To increase the utilization of the interceptors and treatment works through improved regulator control.
- To select least damaging overflow locations when overflows are necessary.
- To use the aerial distribution of rainfall to advantage.

The $3 million program (adjusted to ENR 2100), placed in operation in 1969, consists of a monitoring and control center, 9 remote reading rain gages, 5 remote reading river quality monitoring stations, and modifications at 18 control locations on the interceptor system. At 15 control locations, through which 80 percent of the dry weather flow passes, inflatable Fabridams were installed along with remote controlled regulator gates and depth of flow monitors, both in the trunk sewers and the interceptors. At 3 additional control locations on the principal interceptors, provisions were made to remotely control diversions to the river to ease stresses on the interceptor system.

The Fabridams, operated on low pressure air, were located in the major trunks (5-12 feet in diameter) immediately downstream of the regulator gates. Normally the dams are kept in a fully inflated condition forming a dam to approximately mid-height of the conduits. When storm flows are sufficiently large so as to threaten to surcharge the trunk sewers, as indicated by the flow depth monitoring, the Fabridams may be deflated remotely from the control center.

The purpose of the Fabridams is to provide maximum storage within the trunk system before overflows occur. The remote controlled regulator gates and depth recorders permit continuous control of inflows to the interceptors so they may operate at close to full capacity when handling storm flows. Quality monitoring at various points in the system during storm and dry weather flow conditions have lead to a priority sequencing of overflow points when overflows are necessary.

The program is not directed toward control of the major storms, those which occur once or twice a year or once in several years, but rather the frequent lesser storms where significant control can be attained for a modest investment. A simulation model of the interceptor system and controlled regulators was developed to guide operating personnel and assist in the performance evaluation.

Based upon 27 storms occurring between April 1969 and May 1970, the following accomplishments were reported for the 15 controlled overflow points:

- Incidence of overflow reduced by 66 percent.
- Duration of overflow reduced by 88 percent.
- Total volume of overflow reduced by estimated 35-70 percent.
- Capture of urban runoff increased from 65-77 percent.

Unfortunately, the treatment plant was unable to handle flows in excess of about one-half the interceptor's capacity. Therefore, most of the additional volume intercepted was bypassed untreated at the plant. The major benefit was therefore to transfer the major storm overflow loading on the river from several points within the twin cities to a single point at their downstream boundary. Correction of this deficiency will be accomplished through future plant improvements.

A major accomplishment of the plan is the almost total capture of the spring thaw runoff, which is heavily contaminated due to traffic, icing abatement measures, and mixed dry weather flow.

Under the conclusions of the Sanitary District report the authors note:

> River quality monitors along the urban reaches of the Mississippi River have shown that the physical quality of the water is not appreciably affected by storm

and combined sewer discharges.

Under their evaluation, however, they note:

> . . . the pollution of the urban stretch of the Mississippi River is much less frequent and of shorter duration to increase dramatically the acceptability of the river for boating, hiking, and other recreation.

About 50 percent of the Fabridams had to be replaced in the first two years of service. Most failures were due to anchorage problems which is extremely critical. Other failures were related to air leaks, punctures, and autodeflation. Two of the failures were described as "catastrophic," indicating the failures occurred with considerable sewage in storage thereby releasing flood waves through the overflow pipes.

NEW YORK CITY, NEW YORK

Although the topography of San Francisco makes it unique, in other respects it closely resembles New York City, especially Manhattan Island and the boroughs of Brooklyn and Queens. Both are served by combined sewer systems discharging to saltwater estuaries of major rivers. Both estuaries contain bays and channels with highly developed shores and little tributary flow. Each city system is only one of several important systems discharging wastes to a common body of water. Both are highly developed with property values at a premium and land available for sewage treatment facilities extremely hard to locate.

New York City does not have an adopted master plan which defines wet and dry weather alternative plans. However, it does have an Environmental Protection Agency demonstration facility, the Spring Creek Auxiliary Water Pollution Control Project, which is believed to typify several similar off-line storage projects, such as Boston University Bridge and Humboldt Avenue, Milwaukee.

The Spring Creek facility, completed in 1972 for a total construction cost of $22,300,000 ($6,850 per acre), intercepts combined overflows from a 3,256 acre service area. The total storage capacity of 23.0 million gallons, which includes 10.0 million gallons in basins and 13.0 million gallons through backup in trunk systems, is equivalent to 0.26 inches of runoff. The system is designed to fully contain up to 50 percent of the summer storms and to provide primary treatment and chorination for larger storms. Twenty minutes minimum detention is provided for intensities up to 0.50 inches per hour which covers 98 percent of all storms. The contained volume is drained and pumped to the dry weather flow treatment plant for complete treatment after each storm.

Appurtenances include traveling bridge collectors, mechanically cleaned racks, centrifugal type grit separators, and sodium hypochlorite storage and feed facilities. The treatment unit is completely covered and has 6 parallel contact basins, each 50 feet by 476 feet long.

Twenty overflows, all with the equivalent of primary treatment, are anticipated to occur during each five-month summer season within which time 45 percent of the annual rainfall occurs. If successful, up to six additional basins will be constructed around the receiving water, Jamaica Bay.

WASHINGTON, D.C.

Washington, D.C. began a 50-year sewer separation program in the late 1950's. Costs for fringe areas separated to date have averaged between $21,735 and $32,600 per acre. Recognizing the limitations of separation as a total solution, the program has not been funded since 1970 pending an assessment of alternatives.

A conceptual evaluation described in "Combined Sewer Overflow Abatement Alternatives, Washington, D.C.," Roy F. Weston, Inc., August 1970 for U. S. Environmental Protection Agency followed the earlier approaches in Chicago and Boston recommending a system of deep rock tunnels and mined storage with treatment at Blue Plains, which is the regional dry weather flow treatment plant, and a new wet weather reclamation plant at Kingman Lake. The storage would fully contain the combined area runoff from a 15-year frequency, 24-hour duration storm equivalent to 1,200 million gallons or 4.31 inches of runoff. The combined treatment capacity of the two plants is proposed to be 440 mgd which will permit dewatering of storage from the 15-year storm in less than 3 days. The estimated project cost of $371 million ($36,230 per acre) was considerably less than the estimated cost for total separation ($69,500 per acre).

A second study, "Conceptual Engineering Report Kingman Lake Project," Roy F. Weston, Inc., August 1970, for the Environmental Protection Agency, completed concurrently studied the reclamation aspects of combined sewer overflow abatement. This study recommended 175 million gallons of storage for a 4,066 acre area, which is equivalent to 1.58 inches of runoff, and 50 mgd wet weather flow treatment facility, which will dewater maximum storage in 3.5 days. The treated effluent will be impounded in a surface reservoir and retreated in dry weather periods in transit to a higher quality reservoir. Weather permitting, the process will be repeated a third time producing an effluent suitable for water-contact sports. The total project cost was estimated at $71.9 million or $17,683 per acre.

The District has engaged a consultant to review these and other alternatives and to recommend a master plan program. A reconnaissance-level report has been completed and a comprehensive analysis and action plan is expected within two years.

CONCLUSIONS

Master plans comparable to that of San Francisco are either non-existent or in their infancy thus permitting only the broadest conclusions to be drawn. In addition, the uniqueness of San Francisco hydrologically, where 96 percent of rainfall occurs in seven winter months, further complicates direct comparison.

Recognizing these limitations, the data suggest the following conclusions:

- The level of control of water quality offered by the San Francisco plan is equal to or exceeds any of the plans reviewed.
- High objective plans tend to have lower per acre costs as the project area increases. Hence when dealing on a city or metropolitan area basis there appears to be a distinct economy of scale not evident in a sub-area to sub-area comparison.
- The range of alternative costs in the San Francisco plan compares favorably with plans in other areas when adjusted to a common base.
- The ratio of storage capacity to treatment ratio for San Francisco is low in comparison to other areas thus increasing the Master Plan's reliance and possible vulnerability upon automated monitoring and control. It is noted, however, that this ratio is nominally consistent with the lower average rainfall intensities in San Francisco as compared to eastern and mid-western cities.
- The San Francisco monitoring network is far more comprehensive and advanced than any system reviewed. This accumulation and analysis of data will enhance the credibility and define the needs of the alternate plans before construction is undertaken.
- The conclusions and recommendations of the San Francisco Master Plan follow the general trends and generally leads the plans of other communities. Notable advances in the art of combined wastewater management included in the Master Plan are seen in the City's system control approach utilized in the Master Plan, the "building block" concept including "split flow" treatment, the use of hilly topography to advantage, integrated centralized control of the overall system, cost-effectiveness in treatment/storage/transportation facility sizing, and the integrated industrial waste program.

TABLE VIII-1

Comparison of Master Plan Report with Planning and Projects in Other Cities - Basic Elements

Item	San Francisco		Chicago	Boston	Seattle	Minneapolis -St. Paul	New York	Washington, D.C.	
Study completed, hr.	1972		1972	1967	1971	1971	1968	1970	
Avg. Annual rainfall (1), in.	18.7		33.2	42.8	38.9	24.8	42.4	40.8	
Avg. summer rainfall (May-Sept.), in.	0.8		17.1	16.9	7.2	16.1	19.0	20.3	
Ratio of avg. winter rainfall (Oct.-Apr.) to San Francisco	1.0		0.9	1.4	1.8	0.5	1.3	1.1	
Ratio of 2-year frequency max. 24-hr. rainfall to San Francisco (2)	1.0		1.2	1.4	0.9	1.4	1.6	1.5	
Ratio of 2-yr. frequency max. 1-hr. rainfall to San Francisco (2)	1.0		2.7	2.0	0.6	2.7	2.7	3.1	
Total combined sewered area, acres	24,000		240,000	12,000	23,400 (equiv.)	31,900	3,256	10,240 (D.T.). 4,066 (K.)	
	Alt. A	Alt.D						D.T.	K.
Proposed treatment capacity as a multiple of dry weather flow (3)	8.0	8.0	1.5	21.8	3.0	6.0	1.5	5.9	2.0
Total storage capacity, in. runoff	0.10	0.63	3.14	1.84	0.05	---	0.26	4.31	1.58
Ratio of storage capacity to maximum storm controlled,%	22	31	93	37	---	---	---	78	53
Time required to completely dewater storage at max. treatment rate, hrs.	13	33	1200	48	---	---	37	72	84
Frequency of overflows per year	8	0.2	<0.2	<0.1	---	---	45	<0.1	1.0
Available level of treatment for captured flows	P/S (4)	T	T	chlorination only	P	S	S	T	T
Estimated capital cost per acre (adjusted to 1974 San Francisco costs)	$18,040	$38,790	$12,543	$65,000	---	---	$6,850	$36,230	$17,683

(1) At nearest major airport, 30 years of record.
(2) From U.S. Weather Brueau data.
(3) Includes dry weather capacity where joint use planned.
(4) Split Flow treatment.
"---" indicates no data reported.

Abbreviations: P-primary, S-secondary, T-tertiary, D.T.-deep tunnel, K-Kingman Lake.

TABLE VIII-2

Comparison of Master Plan Report with Planning and Projects in Other Cities - Study Conclusions

	Item	San Francisco	Chicago	Boston	Seattle	Minneapolis -St. Paul	New York	Washington, D.C.
1.	Retain Combined Sewers	Yes	Yes	Yes	Some	Some	Yes	Yes
2.	Goal of Total Elimination of Degradation of Shore-line Waters	Yes	Yes (Lake Michigan)	Yes (Inner Harbor)	Yes (Lake Washington)	Limited	Limited	Yes
3.	Volumetric Reduction of Overflows, %	Alt.A 90 Alt.D 99 +	99+	99+	52	35-70	70?	Kingman 95? Tunnel 99+
4.	Source Control of Toxic Substances	Yes	---	---	---	---	---	---
5.	Estimated Upper Limit of Cost Effective Control, Overflow frequency of less than once in ____ years	5	5	15	1	1	1	25
6.	Environmental Impact of one overflow per year not significantly greater than lower frequency	Yes	No(1)	No(2)	---	---	---	No(2)
7.	Continuing monitoring for Data Base	Yes	Yes	---	Yes	Yes	Yes	Yes
8.	Surface Discharge of Overflow	Yes	No	No	No	---	Yes	No
9.	Substantially Complete floatable and settleable removals	Yes	Yes	No	No	No	Yes	Yes
10.	Provide Disinfection	Yes	Yes	Yes	No	No	Yes	Yes

(1) Flood control was major consideration.
(2) Conclusions not supported by real data.
"---" Indicates no data reported.

TABLE VIII-3

Comparison of Master Plan Report with Planning and Projects in other Cities - Study Recommendations

	Item	San Francisco	Chicago	Boston	Minneapolis -St. Paul	Seattle	New York	Washington, D.C.
1.	Treated Waste be Discharged through Offshore Outfalls	Yes	River	Yes	Yes	River	No	No(1)
2.	Variable Treatment Rate to meet special flow or available dilution changes	Yes	No(2)	No	No(2)	No(2)	No(2)	No(2)
3.	"Building Block" concept to provide flexibility to meet changing water quality requirements	Yes	Yes(3)	No	No	No	No	No
4.	Close coordination with local and regional planning agencies	Yes	Yes	---	Yes	Yes	---	Yes
5.	Release of lands not essential to the project for other uses	Yes	Yes	No	No	No	No	Yes(4)
6.	Implementation schedule variable subject to outside funding (Federal and State)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7.	Policy on the degree of wet weather treatment be subject to cost-benefit analysis	Yes	---	---	---	---	---	---
8.	Immediate upgrading of dwf plants can be undertaken	Yes	Yes	Yes	Yes	Yes	Yes	Yes
9.	Substantial street flooding reduction	Yes	Yes	Yes	No	No	No	Yes
10.	Substantial reduction of degradation of receiving waters	Yes	Yes	Yes	Yes	Yes	Yes	Yes
11.	Integrated industrial waste program	Yes	Yes	No	No	No	No	No
12.	Long range treatment consolidation	Yes	Yes(5)	---(5)	---(5)	---(5)	---	---(5)
13.	Compatability with regional plans	Yes	Yes	---	Yes	Yes	---	Yes
14.	Capability of rail haul of sludge	Yes	Yes	No	---	---	---	---
15.	Hilly topography used to advantage for underground storage	Yes	No	No	No	No	No	No
16.	Direction towards central control system	Yes	Yes	---	Yes	Yes	---	---
17.	"Split flow" treatment of wet weather flows(6)	Yes	Yes	No	No	No	No	Yes

(1) Total reclamation proposed in Kingman project and this combined with river discharge in Deep Tunnel project.
(2) Plans use dry weather flow (dwf) plants to treat retained flows.
(3) Available through flow routing selection through dwf plants. Most studies have not progressed this far in their planning.
(4) Recreational use of treatment ponds proposed.
(5) Major regional dwf treatment plants in existence.
(6) Split flow visualizes operating two plants with different levels of treatment at a single site. When base demands for the higher level plant are less than its maximum capacity, the operator has the option of diverting more flows away from the lower level treatment to the higher improving overall performance.
"---" Indicates no data reported.

Chapter IX

MASTER PLAN COSTS

This chapter discusses the derivation of costs used in the Master Plan and presents tables showing the breakdown of the total Master Plan cost by major elements, by sewerage districts, by degree of wet weather control, and by level of combined dry-wet weather control to be provided.

The cost figures given in this chapter are current and reflect considerable updating by the City since the Preliminary Comprehensive Report was printed in September 1971.

PROGRAM COSTS

The total cost of the Master Plan depends on which of many possible alternatives is selected. Table IX-1 gives the total program cost for the alternatives.

These total costs are further broken down by major elements in Tables IX-2 and IX-3 for each of the two stormwater collection rates considered. Tables IX-4, 5 and 6 give further breakdowns of costs of collection and storage facilities within each sewerage district for 0.1 and 0.3 inches per hour collection rates. Table IX-6 shows the cost of providing 3 force mains for each pump station to increase velocity in the pipes at low pumping rates. In all other tables the cost of single force mains are used.

DERIVATION OF COSTS

Costs used in component pricing have for the most part been derived from construction costs of projects within the City or from construction projects designed by consulting engineers for other cities. In all cases, these costs have been adjusted to reflect a common construction cost level and where necessary have been corrected to reflect San Francisco conditions.

The cost estimates in the Master Plan Report are all based on an Engineering News Record (ENR) construction cost index of 2100. This level is expected to be reached in San Francisco during 1974.

Unit costs for various elements of the Master Plan and of all alternative plans were developed for average construction conditions in San Francisco. These unit costs are presented in Figures IX-1 through 7.

These curves and costs presented in Tables IX-1 through IX-5 include an allowance for contractors' overhead and profit and for engineering and construction contingencies.

There are cost curves in the Master Plan Report for all components except pipe conduits. The City has sufficient data on sewer costs, in Table V-70, Ref. 30. No force main unit costs have been given in the Report. Figure IX-8 has been developed to evaluate the City's unit costs for sewer and force main construction.

With one exception the cost curves shown in the Master Plan Report are sound. The exception is the unit cost curve for the activated sludge process shown on Figure IX-6. The curve represents costs in excess of those for complete secondary treatment plants rather than for the process alone.

The cost curves for retention basins relate cost to storage volume and must be used with other factors in mind. The cost is dependent on basin location and type of basin as well. As noted in an earlier chapter, the breakpoint in cost of 500,000 cubic feet stated in the Master Plan was not adhered to by the City and many basins were found to be feasible in considerably smaller sizes because of these other factors. Figure IX-2 shows the relationship of cost per unit volume of storage in upstream basins, shoreline basins, and tunnels in various types of rock. At 500,000 cubic feet of storage, the cost of average tunnel storage and basin storage are about the same. In sizes over 1 million cubic feet, tunnel storage becomes less costly than upstream basins. Where a number of upstream basins have a combined total of over 1 million cubic feet, it may be advantageous to construct tunnel storage in place of the basins.

Operation and maintenance costs of various alternatives were not considered in the Master Plan Report. It was assumed that these costs would be lower for a single plant than for three or more plants. These costs are important to the phasing of improvements; however, any cost saving would not be realized until such time as the existing plants are completely phased out.

Also not included are costs of abandoning the existing plants. For a proper comparison between alternatives these costs should be included.

Data which were not presented in the Master Plan Report but which are important to evaluation of costs is a breakdown of treatment plant elements. These data have been prepared by the City and are adequate for evaluation of capital costs. Adequate treatment plant operating costs, however, are not available and these are needed for a complete evaluation of alternatives.

The cost data for the conduits and lift stations necessary to consolidate the existing overflows into 15 were not included in the Master Plan Report. As recently developed by the City, this additional cost is approximately $24.5 million.

Additional cost data are also needed for the ocean outfall. There has been some preliminary design work accomplished to make the cost estimates given in the Master Plan Report. These were for different areas of the City, however, with somewhat different conditions. A more detailed estimate is needed for the ocean outfall proposed.

CONCLUSION

This review has been limited to cost estimates used in the Master Plan development. Possible alternative levels of control are not considered. Given that cost estimates are being updated as more data become available, it is appropriate to conclude that the cost estimates are within the accuracy required for planning.

TABLE IX-1

PROGRAM COST [1974 MILLION DOLLARS] FOR COMBINED DRY-WET WEATHER PROGRAMS

Wet Weather Program	Treatment Level (1)	Wet Weather Alternatives A	B	C	D
0.1 in/hr stormwater Collection rate (2)	1	433	502	645	804
	2	482	551	694	854
	3	525	594	737	897
0.3 in/hr stormwater Collection rate (2)	1	466	535	678	838
	2	516	585	728	887
	3	559	628	771	930

(1) Wet weather treatment will be for 1000 mgd and at Level 1 only. Dry weather treatment will be for 250 mgd and at one of the three alternate levels. All costs are for a single treatment facility designed to handle all wastewater flow.

(2) Single pipe force mains.

TABLE IX-2

COST OF MAJOR ELEMENTS [1974 MILLION DOLLARS]

Element		Wet Weather Alternatives A	B	C	D
Collection and Storage Facilities:(1)					
Richmond-Sunset District		44.8	72.9	125.3	182.8
Southeast District		69.9	88.5	129.4	174.1
North Point District		68.3	90.7	140.2	197.7
Crosstown Tunnel		53.0	53.0	53.0	53.0
Westside Tunnel		40.2	40.2	40.2	40.2
Ocean Outfall		44.4	44.4	44.4	44.4
	Subtotal	320.6	389.7	532.5	692.2
Southwest Treatment Plant					
Level 1 — 1000 mgd(2)		112.2	112.2	112.2	112.2
	Subtotal	432.8	501.9	644.7	804.4
Level 2 — 250 mgd		49.3	49.3	49.3	49.3
	Subtotal	482.1	551.2	694.0	853.7
Level 3 — 250 mgd		43.1	43.1	43.1	43.1
	Total	525.2	594.3	737.1	896.8

(1) With collection rate equivalent to 0.1 in/hr of rainfall — this is the maximum flow rate that the system can convey to the treatment facility.

(2) Cost assumes 15 million dollar return for abandonment of existing treatment facilities.

TABLE IX-3

COST OF MAJOR ELEMENTS
[1974 MILLION DOLLARS]

		Wet Weather Alternatives			
Element (1)		A	B	C	D
Collection and Storage Facilities:					
Richmond-Sunset District		49.3	77.4	129.9	187.3
Southeast District		86.0	104.6	145.5	190.2
North Point District		81.1	103.5	153.0	210.5
Crosstown Tunnel		53.0	53.0	53.0	53.0
Westside Tunnel		40.2	40.2	40.2	40.2
Ocean Outfall		44.4	44.4	44.4	44.4
	Subtotal	354.0	423.1	566.0	725.6
Southwest Treatment Plant					
Level 1 — 1000 mgd (2)(3)		112.2	112.2	112.2	112.2
	Subtotal	466.2	535.3	678.2	837.8
Level 2 — 250 mgd (3)					
Dry Weather Flow		49.3	49.3	49.3	49.3
	Subtotal	515.5	584.6	727.5	887.1
Level 3 — 250 mgd (3)					
Dry Weather Flow		43.1	43.1	43.1	43.1
	Total	558.6	627.7	770.6	930.2

(1) With collection rate equivalent to 0.3 in/hr of rainfall — this is the maximum flow rate that the system can convey to the treatment facility.

(2) Cost assumes 15 million dollar return for abandonment of existing treatment facilities.

(3) Peak capacities — mean dry weather flow 100-125 mgd.

TABLE IX-4

STORMWATER COLLECTION AND STORAGE SYSTEM COSTS [1974 MILLION DOLLARS]

	Wet Weather Alternatives			
Elements	A	B	C	D
Richmond-Sunset District				
Upstream Retention Basins	14.9	32.4	68.5	106.5
Gravity Conduits	4.4	10.3	10.4	10.4
Shoreline Retention Basins	15.3	17.7	28.7	41.7
Pump Stations (1)	4.0	4.0	4.0	4.0
Force Mains (1)	2.2	2.2	2.2	2.2
Tunnel Storage	2.5	4.8	10.1	16.5
Bypass Consolidation	1.5	1.5	1.5	1.5
Total	44.8	72.9	125.3	182.8
Southeast District				
Upstream Retention Basins	1.3	2.4	4.3	6.5
Gravity Conduits	16.9	16.9	16.9	16.9
Shoreline Retention Basins	16.6	26.9	50.8	80.1
Pump Stations (1)	9.3	9.3	9.3	9.3
Force Mains (1)	5.9	5.9	5.9	5.9
Tunnel Storage	10.4	17.6	32.7	45.9
Bypass Consolidation	9.5	9.5	9.5	9.5
Total	69.9	88.5	129.4	174.1
North Point District				
Upstream Retention Basins	5.2	9.6	17.6	27.5
Gravity Conduits	8.4	9.3	9.7	9.7
Shoreline Retention Basins	16.8	26.9	51.8	82.3
Pump Stations (1)	9.4	9.4	9.4	9.4
Force Mains (1)	6.4	6.4	6.4	6.4
Tunnel Storage	8.6	15.6	31.8	48.9
Bypass Consolidation	13.5	13.5	13.5	13.5
Total	68.3	90.7	140.2	197.7

(1) With collection rate equivalent to 0.1 in/hr of rainfall

TABLE IX-5

STORMWATER COLLECTION AND STORAGE SYSTEM [1974 MILLION DOLLARS]

Elements		Wet Weather Alternatives A	B	C	D
Richmond-Sunset District					
Upstream Retention Basins		14.9	32.4	68.5	106.5
Gravity Conduits		4.4	10.3	10.4	10.4
Shoreline Retention Basins		15.3	17.7	28.7	41.7
Pump Stations (1)		7.7	7.7	7.7	7.7
Force Mains (1)		3.0	3.0	3.0	3.0
Tunnel Storage		2.5	4.8	10.1	16.5
Bypass Consolidation		1.5	1.5	1.5	1.5
	Total	49.3	77.4	129.9	187.3
Southeast District					
Upstream Retention Basins		1.3	2.4	4.3	6.5
Gravity Conduits		16.9	16.9	16.9	16.9
Shoreline Retention Basins		16.6	26.9	50.8	80.1
Pump Stations (1)		21.6	21.6	21.6	21.6
Force Mains (1)		9.7	9.7	9.7	9.7
Tunnel Storage		10.4	17.6	32.7	45.9
Bypass Consolidation		9.5	9.5	9.5	9.5
	Total	86.0	104.6	145.5	190.2
North Point District					
Upstream Retention Basins		5.2	9.6	17.6	27.5
Gravity Conduits		8.4	9.3	9.7	9.7
Shoreline Retention Basins		16.8	26.9	51.8	82.3
Pump Stations (1)		19.5	19.5	19.5	19.5
Force Mains (1)		9.1	9.1	9.1	9.1
Tunnel Storage		8.6	15.6	31.8	48.9
Bypass Consolidation		13.5	13.5	13.5	13.5
	Total	81.1	103.5	153.0	210.5

(1) With collection rate equivalent to 0.3 in/hr of rainfall.

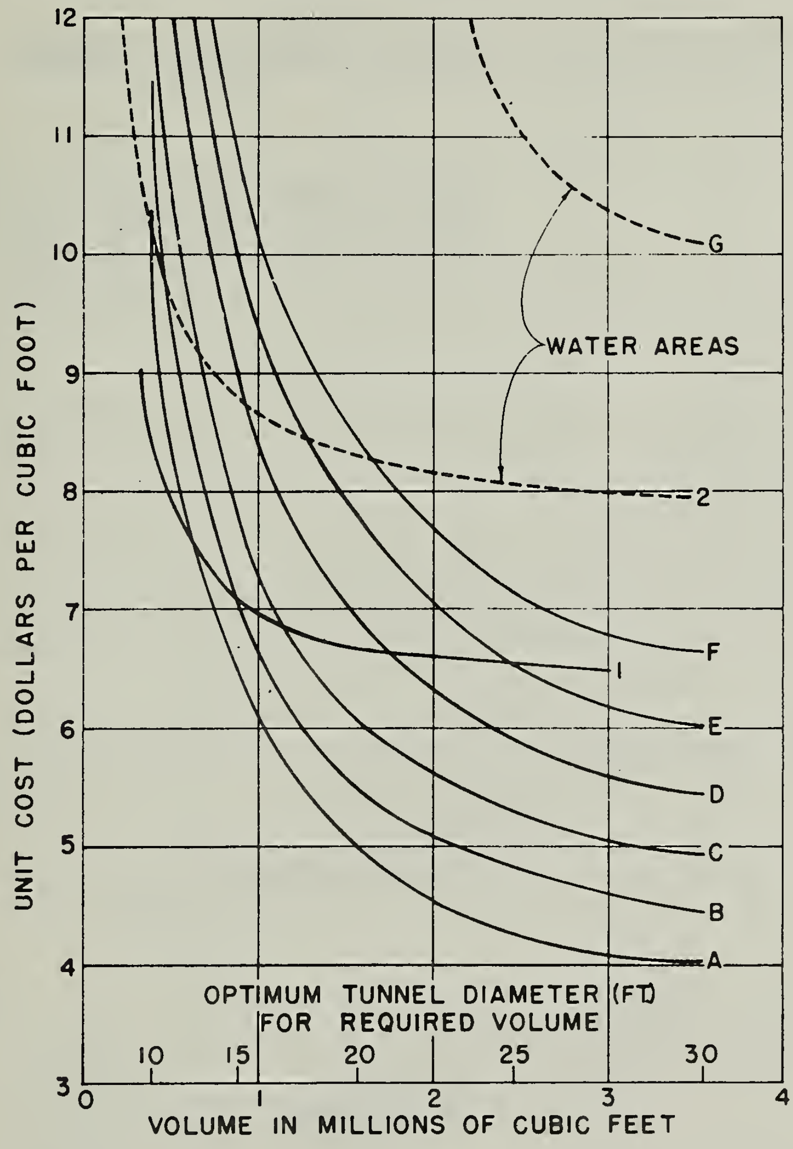
TABLE IX-6

FORCE MAIN COSTS
ONE PIPE vs. THREE PIPES
[1974 MILLION DOLLARS]

Stormwater Collection Rate (in/hr.)	No. Pipes	North Point	Southeast	Richmond-Sunset
0.1	1	6.4	5.9	2.2
	3	11.3	9.9	——
Cost Increase		4.9	4.0	
0.3	1	9.1	9.7	3.0
	3	15.1	13.0	——
Cost Increase		6.0	3.3	

Figure IX-1

COST COMPARISON PER UNIT VOLUME RETENTION BASINS AND TUNNELS



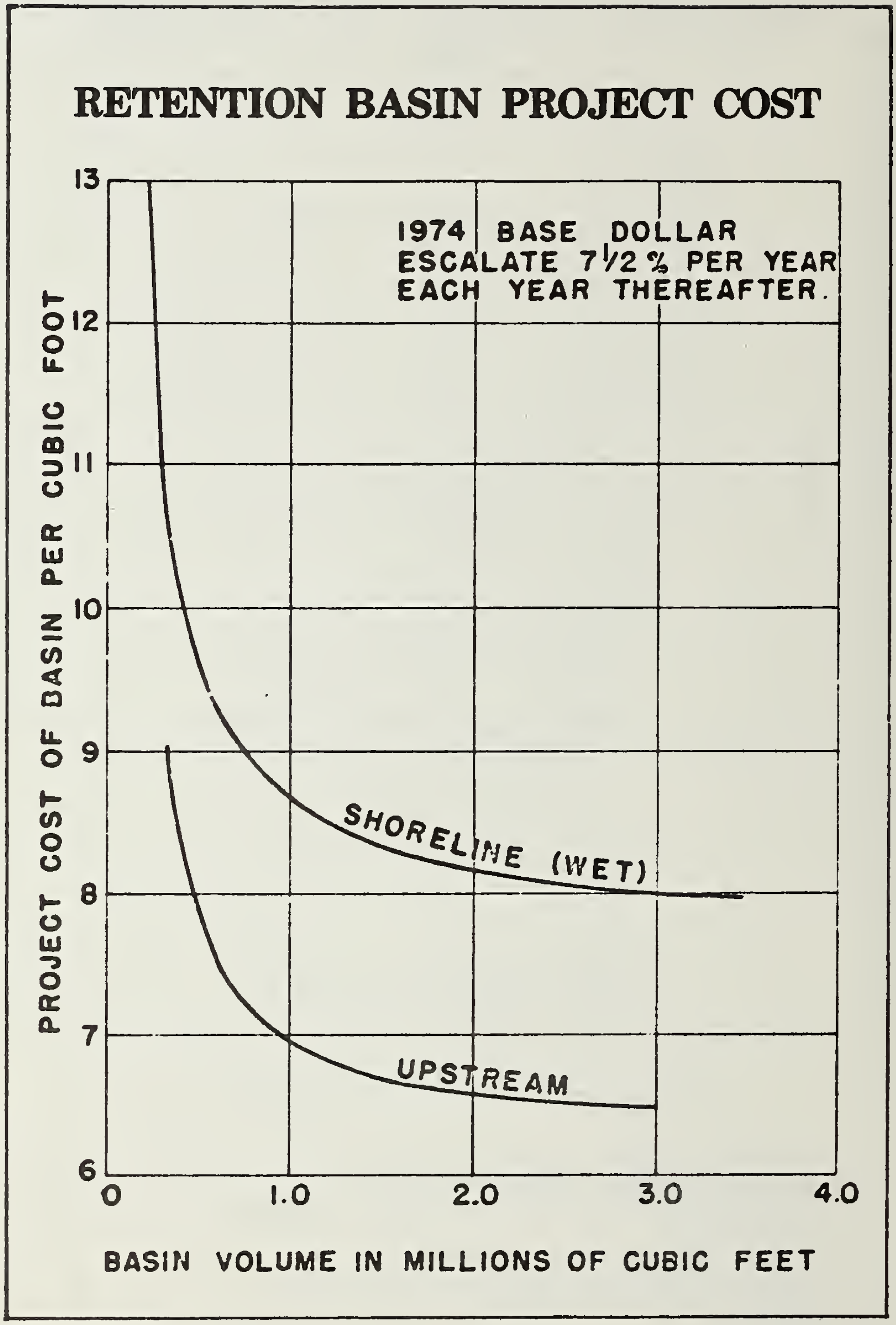
1. UPSTREAM BASIN
2. SHORELINE BASIN (WATER AREAS)

TUNNEL COST BASED ON 5,000 FOOT LENGTH

A. SANDSTONE
B. SAND, COMMON & SANDSTONE
C. CHERT, BASALT, SERPENTIZED PERIDOTITE
D. SANDSTONE, FAULT ZONE
E. SAND
F. CHERT, BASALT, SERPENTIZED PERIDOTITE, FAULT ZONE
G. FILL AREAS UNDER AIR PRESSURE (WATER AREAS)

Reference 2-Plate VI-5

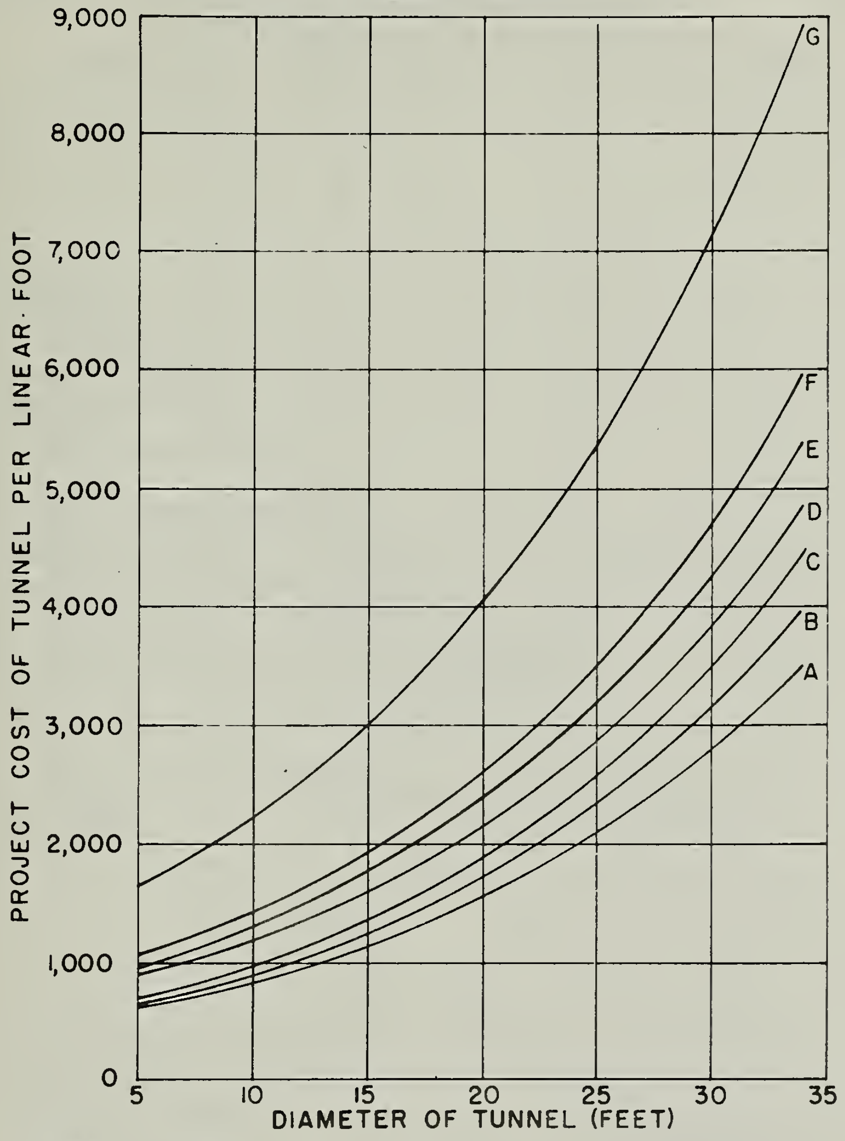
Figure IX-2



Reference 2-Plate VI-6

Figure IX-3

TUNNEL COST



A. SANDSTONE
B. SAND, COMMON & SANDSTONE
C. CHERT, BASALT, SERPENTIZED PERIDOTITE
D. SANDSTONE, FAULT ZONE
E. SAND
F. CHERT, BASALT, SERPENTIZED PERIDOTITE, FAULT ZONE
G. FILL AREAS UNDER AIR PRESSURE

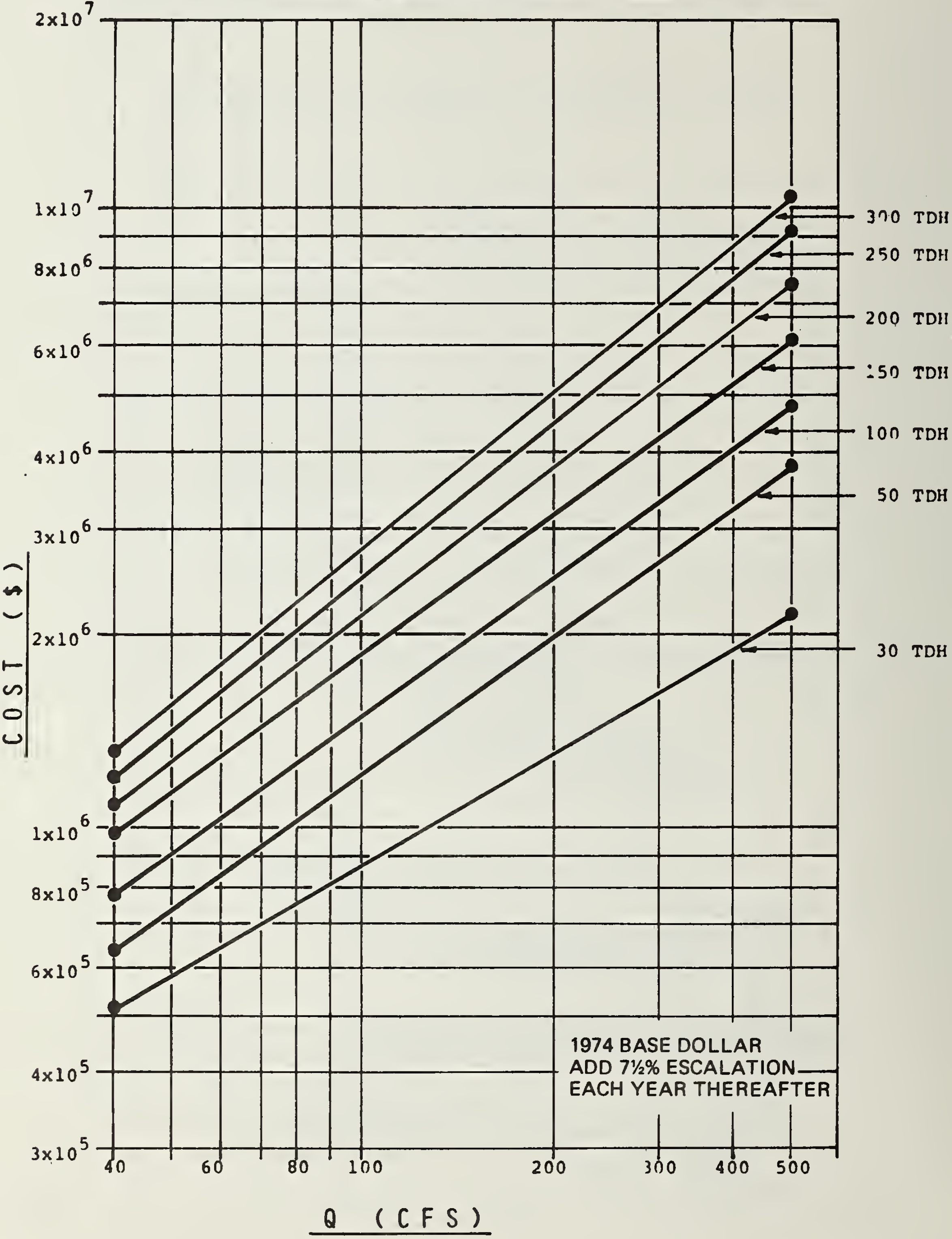
NOTES:

1. COSTS ARE 1974 BASE DOLLAR. ESCALATE 7½ % PER YEAR, EACH YEAR THEREAFTER.
2. PRICES APPLICABLE TO 5,000 FT. TUNNEL. FOR EACH 1,000 FEET LESS, INCREASE UNIT BID PRICE BY 10%.
3. MINIMUM LENGTH TUNNEL 1,000 FEET.

Reference 2-Plate V-29

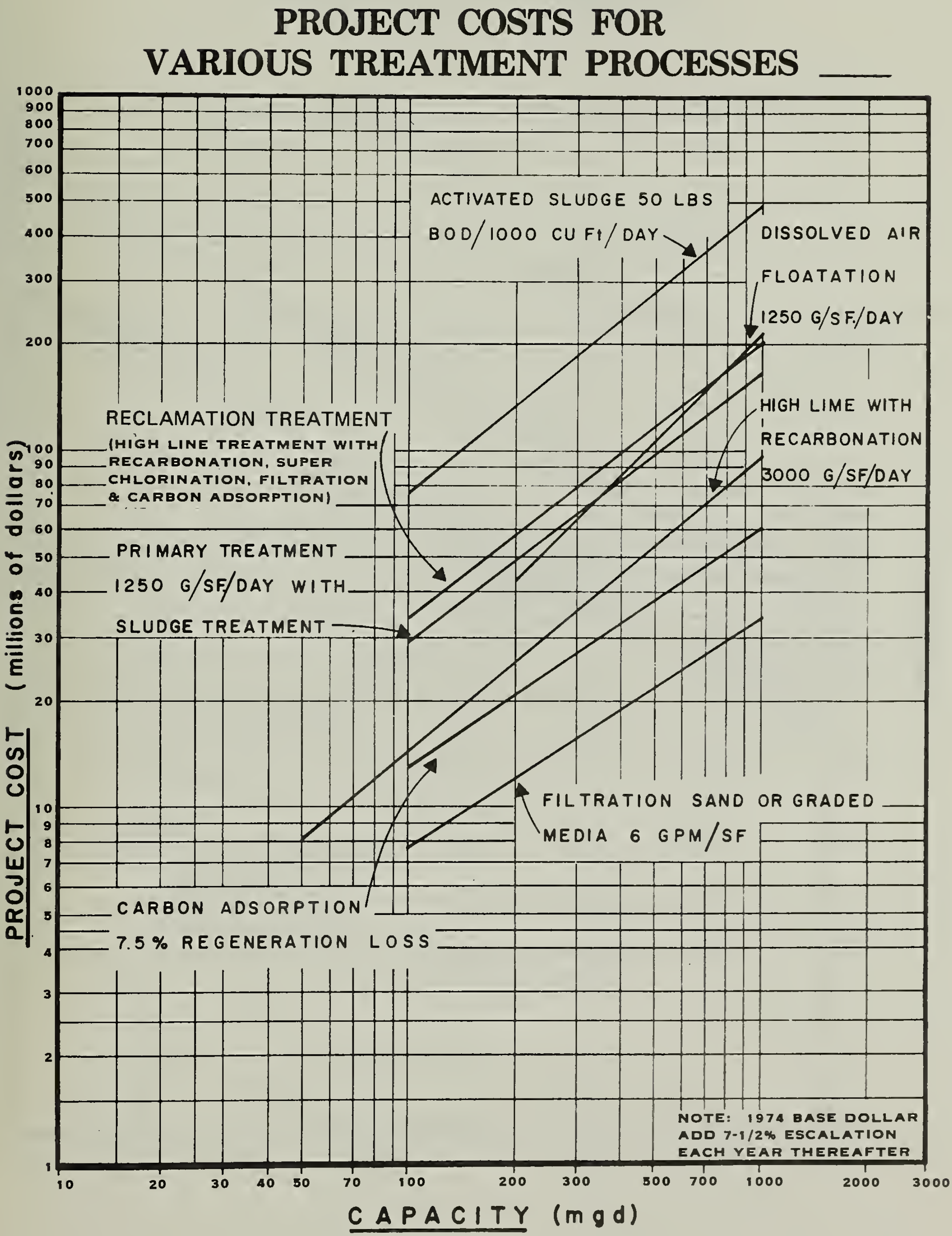
Figure IX-4

PUMP STATION PROJECT COST VS. FLOW



Reference 2-Plate V-30

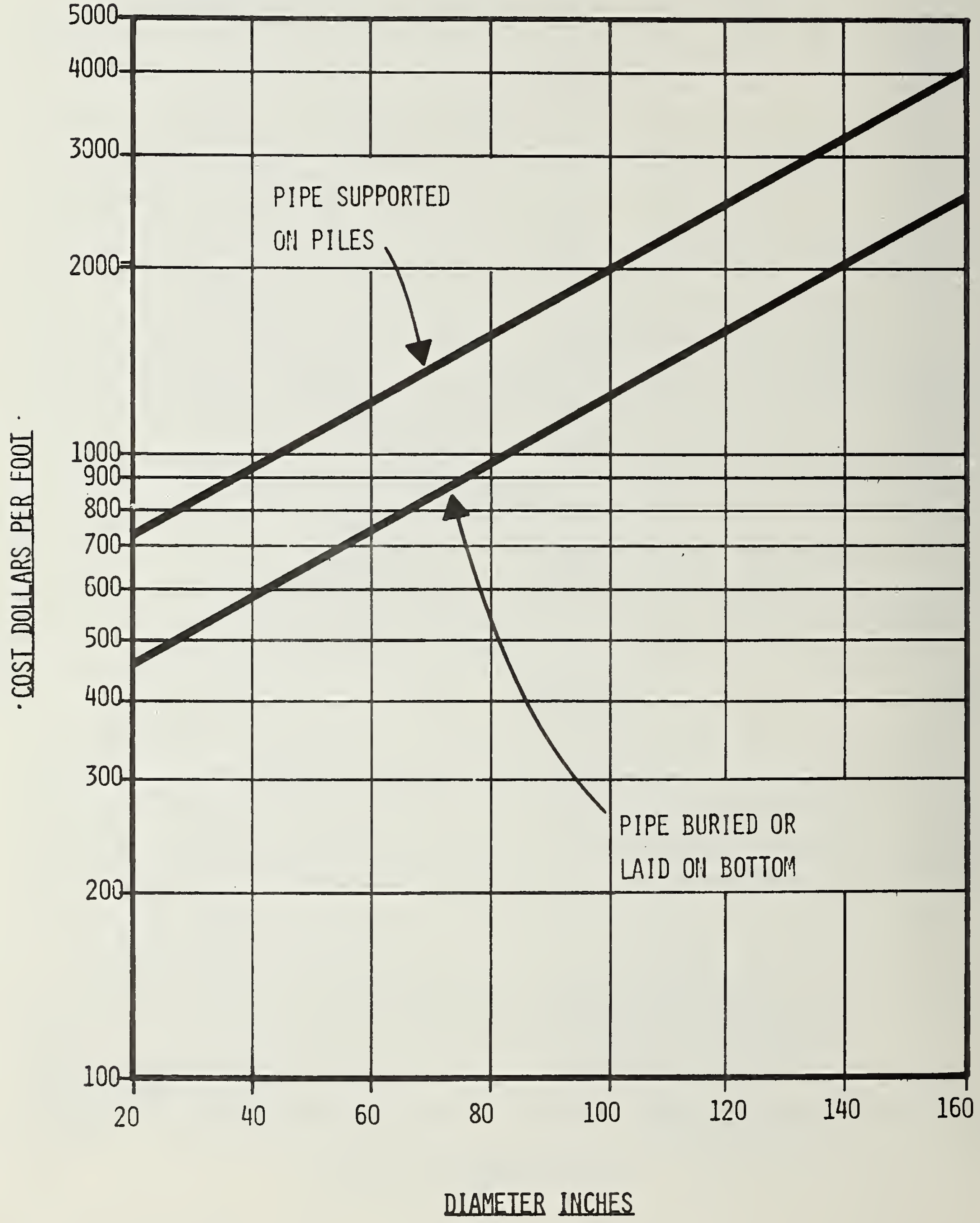
Figure IX-5



Reference 2-Plate V-28

Figure IX-6

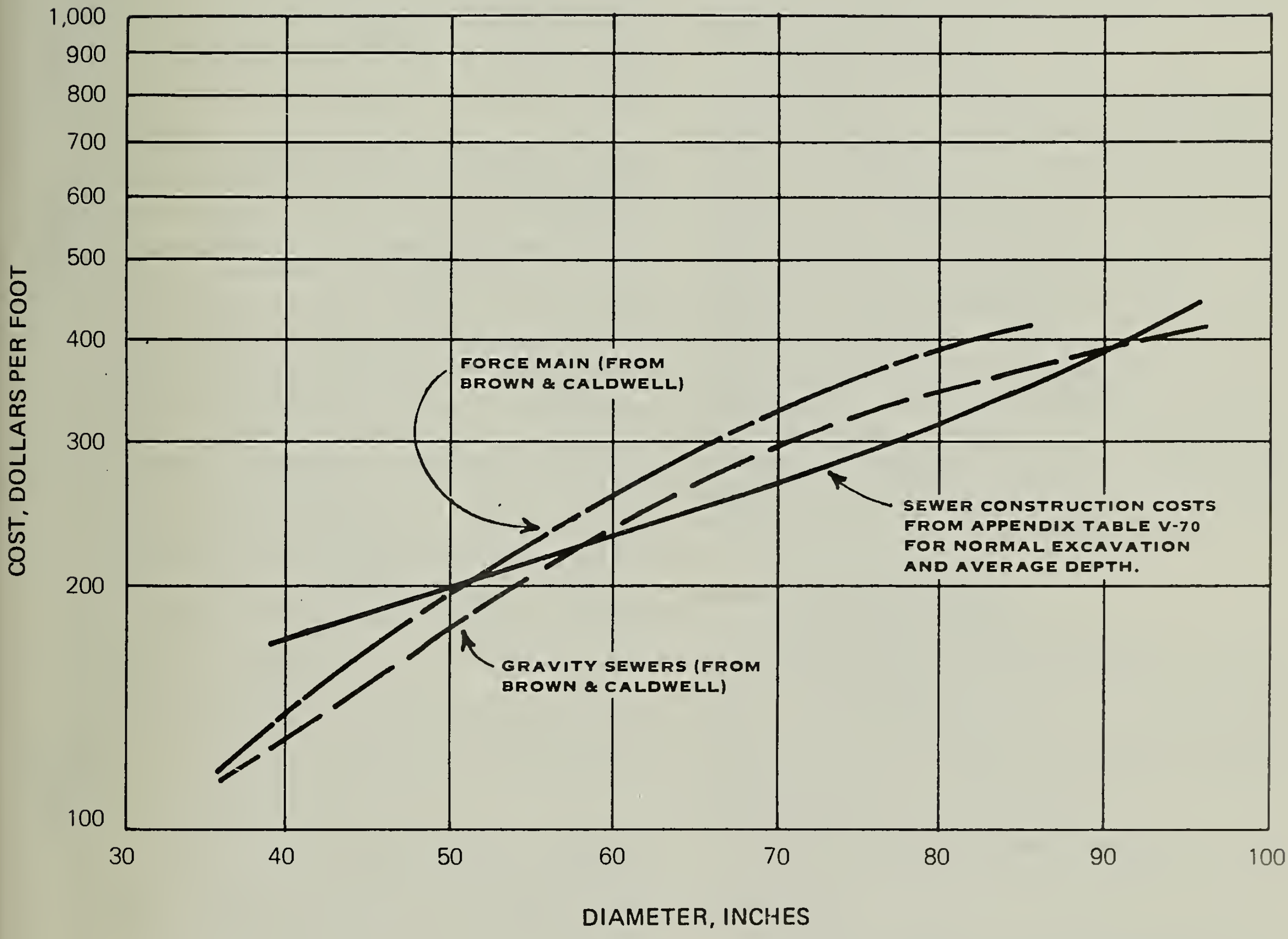
UNIT PROJECT COST OF SUBMARINE OUTFALL SEWERS – 1974



Reference 2-Plate V-32

Figure IX-7

UNIT COST OF FORCE MAIN AND GRAVITY SEWERS



Chapter X

COST EFFECTIVENESS

Cost-effectiveness analysis is necessary in evaluating engineering projects to assure that major problems are resolved expeditiously, avoid unnecessary expenditure, and optimize the benefits of the project per dollar expended as implementation proceeds. Recently water quality control laws and regulatory agencies have begun to require formal cost-effectiveness analyses as a condition for government financial assistance for water quality control projects.

In the case of San Francisco, the State Water Resources Control Board and the Environmental Protection Agency have placed the following condition on approval of a grant for construction of waste collection and treatment facilities:

> "The Municipality shall by April 1, 1973, submit a staged wet weather program whose aim shall be to eliminate the discharge of untreated wastewater to the aquatic environment . . . consideration of Stage I improvements shall include a thorough cost-effective evaluation of various alternative plans taking into account pollutant removal accomplishments, costs, impact on beneficial uses of receiving waters, and environmental impacts. A sufficient number of alternative Stage I improvement plans shall be compared and presented to display a broad range of investments . . ."

In addition, the following provision of the 1972 Federal Water Pollution Control Act bases grant eligibility for wastes containing storm waters on cost-effectiveness analysis:

> ". . . 'treatment works' means any other method or system for preventing, abating, reducing, storing, treating, separating, or disposing of municipal waste, including storm water runoff, or industrial waste, including waste in combined storm water and sanitary sewer systems. Any application for construction grants which includes wholly or in part such methods or systems shall . . . contain adequate data and analysis demonstrating such proposal to be, over the life of such works, the most cost efficient alternative . . ."

A formal cost effectiveness analysis provides assurance to governmental agencies and the public that funds are being invested in projects that will provide the maximum benefit.

The San Francisco Master Plan was developed, in part, in response to a requirement of the California Regional Water Quality Control Board specifying that the City must submit a plan to eliminate the bypassing of untreated wastewater. This requirement raises numerous questions related to project cost-effectiveness.

Complete elimination of bypass from a system in which flows are dependent upon rainfall is an unrealistic goal. Hydrologic events occur randomly and when presented as a frequency distribution illustrate the declining necessity and increased cost per benefit for facilities designed to control rare events. In most cases, the cost-effect ratio for controlling such infrequent events is unfavorable. While elimination of bypass may be impractical, elimination of deleterious effects from bypasses is a goal which should be diligently pursued. Unfortunately, the level of control for degree of bypass reduction, at which deleterious effects cease or become insignificant is not easily defined. Definition of the desirable level of control thus becomes the aim of the cost-effectiveness analysis.

BASIC ALTERNATIVES

Numerous alternate approaches could be used to control wastewaters from San Francisco. However, many can be eliminated in cursory comparisons because of inconsistencies with regulatory requirements or obviously inferior cost-effect relationships. The Master Plan Report eliminates several alternatives in this manner.

Factors or restrictions leading to early elimination of several alternative facility configurations include:

- Secondary treatment of dry weather flows required by the Federal Water Pollution Control Act of 1972.
- Extremely high project costs.
- Extreme disruption of normal urban activity.
- Economics of scale favoring construction of a small number of regional facilities over a large number of local facilities.
- Operation and maintenance problems associated with dispersed wet weather flow treatment facilities.
- Land use and value restrictions.

- Better dispersion of pollutants by ocean discharge as opposed to bay discharge.
- Spatial and temporal variation of rainfall on San Francisco.
- Pollution potential of urban stormwater runoff.
- Dense population of the San Francisco Peninsula.

The first alternative normally considered for all combined systems in recent years has been sewer separation. This can be quickly eliminated because of extremely high costs (in excess of $3 billion), excessive disruption of normal urban activity, and the water quality problems that may result from separate stormwater discharge in the highly urbanized San Francisco area. After elimination of this option, alternate means of controlling combined sewer flows can be considered. Although numerous facility combinations are possible, some basic approaches are definable. Since combined sewage contains large quantities of pollutants, some treatment process is a basic requirement of all options.

One approach is to install treatment devices at each of the 41 bypass locations or at a smaller number of consolidated bypasses. This alternative has been eliminated due to its high costs, severe operation and maintenance problems from the many treatment plants, and the fact that bay discharge would continue.

Expanding existing facilities to handle wet weather flows is unacceptable due to land use conflicts at the North Point and Richmond-Sunset treatment plants, inability to take full advantage of temporal and spatial rainfall variation, and continued bay discharge

To eliminate bay discharge, some type of transport system must be constructed. The need for such a facility, the economy of scale, and spatial and temporal variation of rainfall favor a single large treatment facility for control of wet weather flows. However, the size and operational problems of a treatment facility required to handle any significant storm flow are prohibitive.

An alternate approach to treatment as a means of control is storage. Sufficient storage to allow utilization of the excess capacity of existing treatment facilities would require space not available in San Francisco without excessive disruption of normal urban activity.

The obvious solution is some combination of storage and treatment capacity. Central storage receiving flow from the entire area would take best advantage of rainfall variation. However, drainage in San Francisco is outward from the center, which reduces the feasibility of this approach. To take full advantage of capacity, storage should have the largest possible tributary area.

From this point, the Master Plan concept was developed:

- One wet weather flow treatment plant located at Lake Merced.
- Shoreline storage basins for the fifteen major drainage basins (upstream basins have been utilized to reduce the inadequacy of sewers and control flooding).
- A crosstown transport system.

Alternative combinations and staging programs for these basic facilities are the subject of the cost-effectiveness analysis.

DETERMINATION OF EFFECTIVENESS

The first step in analyzing the effectiveness of alternative combinations and staging programs is to define methods of measuring and presenting project effectiveness.

A definite relationship exists between water quality control equipment or facilities, the level of control attainable from operation of those facilities, and the benefits resulting from the available level of control. Facilities are precisely definable in all respects. The level of control attainable with the facilities generally can be determined in most respects. Benefits accrued from construction and operation of facilities or a given level of control are the most difficult to precisely define.

In some cases a level of control may be a direct benefit. Such is not normally true in water quality projects. Control parameters such as removal efficiency, effluent quality, and mass emission rates are not direct measures of benefit. Attempts to relate these parameters to benefits, that is, improvement or protection of the receiving waters, have been imprecise at best.

For combined sewage and stormwater overflows, control facilities perform the following functions:

- Reduce untreated bypass
- Remove pollutants from waste stream
- Divert flows to more desirable discharge locations
- Reduce street flooding

The degree of control is directly related to facility design.

Control related parameters commonly used as measures of project effectiveness for water quality control are:

- Effluent bacteriological quality
- Mass emission rates
- Bypass frequency and quantity
- Initial dilution of effluent with receiving water
- Location of discharge
- Frequency of street flooding

Benefits which can be accrued from control are:

- Reduction of health hazard to swimmers and recreationists
- Improved aesthetics of water bodies and shoreline areas
- Protection of the aquatic environment
- Reduction of the numerous problems associated with street flooding

The degree of benefit is related to level of control, receiving water condition, public exposure to wastes, public use of the waters, value of the aquatic environment, and other factors.

Some benefit-related parameters which can be used as a measure of project effectiveness for water quality control are:

- Days per year aesthetics are impaired
- Miles of contaminated or polluted beaches
- Days per year water is safe for swimming
- Number of recreationists adversely affected
- Receiving water quality for physical and chemical parameters
- Diversity, number, and health of aquatic species

The optimum cost-effectiveness comparison results when effectiveness can be quantified. To obtain sufficient data for comparison, control parameters are normally used. Benefits are difficult to quantify and frequently the data obtained are based on qualitative observations.

Substantial information is available concerning the degree of control from various hydraulic and wastewater treatment facilities. The major difficulty in applying benefit parameters as a measure of effectiveness results from the predictive nature of cost-effect analyses. Quantifying benefit parameters from measured or observed data is difficult but numerically defining the benefit resulting from various facility configurations is much more complex.

In view of the differences in availability of information, control parameters are used in this analysis to quantify effectiveness while benefit parameters will be used only as qualitative or general indicators.

ANALYSIS OF ALTERNATIVE PROGRAMS

Facilities combined to form the alternatives are drawn from two basic sources: The Master Plan Report (Ref 1) and the Environmental Impact Statement — Dry Weather Water Pollution Control Project (Ref. 34).

Priorities of Control

Regulatory restrictions and time schedules force certain limitations on control options and make staging and early fulfillment of certain controls highest priority. The primary regulatory restriction is early secondary treatment of dry weather flows. The next priorities are control of bypass in the north shore and ocean beach areas. All alternative programs developed for this analysis are analyzed for compatability with these basic priorities.

Because insufficient information is available for comparison of wet weather control level alternatives for the entire system, standard wet weather facilities are used which provide a single intermediate level of control. In this manner staging programs as well as basic facility combinations can be compared. Since ultimate control is equivalent between alternatives, cost and time of goal attainment are the determining factors. To determine time of goal attainment with respect to cost, a constant expenditure rate of $25 million per year is used. In this manner all alternatives are equivalent with respect to ultimate level of control and expenditure rate leaving timing of goal attainment the determining factors for the effectiveness of the alternative staging programs.

Level of Control

The following facilities or levels of control are used to standardize alternatives.

- Alternate B storage as defined in the Master Plan Report.
- Level II dry weather treatment (250 mgd peak).
- Level I wet weather treatment (1,000 mgd peak).
- Transport system sized to control a rainfall rate of 0.3 inches per hour on the tributary area to a maximum of 1,000 mgd in any conduit.
- Three force mains per pump station to reduce retention time.
- North Point treatment plant utilized as wet weather facility whenever possible.

Effectiveness

The following control related goals are utilized to determine the effectiveness of the staging programs:

1. Interim improvements of dry weather Bay discharges. (Secondary treatment of Southeast and improvements of North Point outfall).(This goal is applicable only to alternative DW-1).

2. Secondary treatment of all dry weather discharges to the Bay.
3. Elimination of all dry weather discharges to the Bay.
4. Secondary treatment of all dry weather flows.
5. Ocean disposal of all dry weather flows.

5a. Deep ocean disposal of all dry weather flows.

6. Significant reduction of wet weather bypass — Northern beaches.
7. Significant reduction of wet weather bypass — Ocean Beaches.
8. Significant reduction of wet weather bypass — Eastside beaches.
9. Treatment of most wet weather discharges.
10. Essentially complete elimination of bypass — North area.
11. Essentially complete elimination of bypass — Ocean side.
12. Essentially complete elimination of bypass — Eastside.

With the exception of the staging program presented in the Master Plan Report, alternates are designed to attain goals in numerical order to the maximum degree possible.

All goals are considered to be attained when the goal considered or a superior goal is accomplished. For example, goal 4 is superior 4 to goals 1 and 2, therefore, goals 1 and 2 are considered to be accomplished when goal 4 is achieved.

Although these goals are primarily qualitative in nature, they represent essentially equivalent control levels in the context of the analysis.

Very qualitative benefits can be associated with these goals. However, such an association would not contribute to the analysis results.

Control of street flooding by storm flows is not included as a goal. The omission of this goal requires separate consideration of the cost-effectiveness with respect to control of street flooding; of transferring upstream retention basin storage capacity to tunnel storage.

Costs

Cost data used in the analysis are taken from information used to derive costs presented in the Master Plan Report and the Dry Weather Project Environmental Impact Statement. Capital cost inconsistencies occur in these reports particularly for treatment plants. Such inconsistencies are resolved by selecting the cost from one source, after consultation with the city, for use with all equivalent facilities. Most operation and maintenance costs are derived from the Dry Weather Project Environmental Impact Statement information although some maintenance costs are based on estimated man-hours and materials required and labor costs.

The economic analysis performed for comparison of alternatives consists of calculating present worth values. The present worth of each is determined on the basis of a $25 million per year capital expenditure and 4.5 percent interest rate. Project lives are assumed as follows: tunnels — 80 years, treatment plants — 30 years, sewers and force mains — 60 years, outfalls — 70 years, pump stations — — 30 years, and retention basins — 50 years. The present worths were calculated on the basis of a 120-year period.

Alternatives

The staging, facilities, capital costs, operation and maintenance costs, present worth values, and goal attainment order for the eight most feasible alternatives considered are given on Tables X-1 through X-8.

The groupings and relationships between alternatives within the groupings are as follow:

Master Plan — No Separate Dry Weather Improvements

MP	Storage in the Marina and North Beach area, followed by Oceanside wet weather control. Then crosstown tunnel for Southeast and North area wastes (staging program proposed in the Master Plan).
MP-1	Crosstown tunnel with secondary treatment for dry weather flows at Southwest treatment plant (Lake Merced), followed by expansion of treatment plant for wet weather flows and completion of storage and transport facilities. (Facility reordering to be consistent with analysis priorities.)
MP-2	Same as MP-1 with volume of tunnel increased for storage to reduce need for upstream retention basins. (Greater centralization of storage than MP-1.)

Emphasis on Dry Weather Compliance — Followed by Alternate MP-1 facilities

DW	Entire dry weather project with ocean disposal followed by Alternate MP-1 facilities.
DW-1	Secondary treatment for Southeast flows and improvement in North Point outfall, followed by Alternate MP-1 facilities.
DW-2	Dry weather project Phase I (North Point to Southeast with secondary treatment and Bay discharge), followed by MP-1 facilities. (Duplicated wet weather and dry weather control facilities eliminated from Alternate DW)

DW-3 Same as DW-2 except transportation from North Point to Southeast utilizes portions of the wet weather tunnel system.

Emphasis on Dry Weather Compliance — Followed by Local Wet Weather Treatment

Dry weather project Phase I followed by wet weather treatment facilities at Richmond-Sunset and Southeast. Alternate C storage is used to compensate for loss of control available with single treatment plant.

Comparison of Alternatives

Based upon the goals previously discussed and the $25 million annual capital expenditure rate, the times required to obtain each goal are shown on Figure X-1 from which the following conclusions are made:

- The time required to attain any goal can be reduced, up to a point, in direct proportion to the rate at which funds are made available. The 25 to 30-year period for project completion appears excessive and can be reduced by as much as one-half by doubling the rate of expenditure. Further reductions in scheduling are very unlikely under the most optimistic economic conditions due to time requirements for resolution of problems, design, and construction.
- The most economical alternative (MP-2) is to implement the Master Plan with storage provided in the tunnel rather than upstream retention basins. The effect of this storage transfer on the cost of the program to control flooding must be evaluated before the true cost effectiveness of the storage transfer can be fully understood. Unfortunately, MP-2 has a definite cost-effect disadvantage during the first phase due to the delay in achieving secondary treatment.

  The Plan which most rapidly achieves wet weather goals and provides very significant improvement in dry weather environmental control (DW-1) is secondary treatment for Southeast flows only and improvement of the North Point outfall, followed by implementation of the wet weather program. This staging program could achieve secondary treatment for Southeast flows prior to 1977, but North Point will remain primary for a long time period during a portion of which the effluent will be discharged to the Bay. Although the 1977 deadline for secondary treatment probably could not be achieved at all treatment facilities by this staging program, it is considered the most cost effective.

The most efficient staging program for regulatory compliance (DW-2) is initial construction of Phase I of the dry weather plan. Incorporating the tunnel design from MP-2 into this staging program would yield the superior alternative considering both present worth and timing of goal attainment. This alternative is free of many of the potential delays which would likely arise from governmental and construction problems associated with the crosstown tunnel and Southwest treatment plant. Much of the governmental processing and design preparation has been completed for the first phase of alternative DW-2.

No economic benefit results from construction of the northern section of the crosstown tunnel in place of dry weather plan Phase I facilities for transport of dry weather flows from North Point to Southeast.

RECOMMENDED STAGING

Based on the comparison of alternatives, a staging program similar to alternate DW-2 is recommended. Because of the obvious cost advantage and possible control improvement, transfer of upstream retention basin storage to the crosstown tunnel should be carefully considered. Figure X-2 shows the facility configuration of the recommended program.

Phase I

Sufficient information is currently available upon which to recommend facility sizings and control levels for first phase facilities. Selection of facilities sizings and control levels for following phases should be based on cost-effectiveness analyses for each project phase prior to design. Recommended Phase I facilities and their costs are listed in detail on Table X-9 has shown on figure X-3. Recommended facilities include Alternate B storage capacity (as defined in the Master Plan Report) at basins 21-1 and 24-1. The greater storage at 21-1 is suggested to reduce overflow frequency and volume to an acceptable level for the highly utilized Marina and Aquatic Park areas. Alternate B storage is recommended at 24-1 to compensate for the lack of upstream basins in the tributary area. Alternate A storage is considered adequate at 28-1 because of the reduced effect of bypasses from this basin on the more heavily used areas of the north shore.

Phase I facilities are summarized as follows:

Element	Cost [$\$10^6$]
1. Pipeline from North Point to Southeast	24
2. Upgraded and expanded Southeast STP	92
3. Improved Southeast outfall	7
4. Upgraded Richmond-Sunset STP	13
5. North shore wet weather treatment, storage, and transport facilities	38
6. Transport system from Richmond-Sunset to Southwest	25
7. Wet weather capacity ocean outfall	30

Completion of Phase I facilities will result in compliance with secondary treatment requirements for dry weather flows and reduction of overflows to important north area beaches to an average of less than five overflows per year. Recommended Phase I facilities and costs are shown Table X-9. Details of recommended Phase I estimated control levels are shown on Table X-10 for treatment plants and Table X-11 for retention basins and wet weather transport facilities.

It is expected that operation of recommended Phase I facilities in conjunction with improvements made to other wastewater discharges to the bay, will result in substantial improvement of the aquatic environment of the bay, particularly in nearshore waters adjacent to San Francisco during the winter and spring months. Another benefit will be a reduction of average annual days in which bacteriological swimming standards are exceeded. At North Shore beaches violations on less than 20 days per year are expected. Normally these days will occur during the least desirable periods for swimming and beach recreation. Also, the aesthetic quality of waters and beaches in the Marina, Aquatic Park, and Firsherman's Wharf areas should be substantially improved except during the worst storm conditions.

The retention basins constructed as a portion of Phase I will be designed to facilitate expansion. Such design will prove helpful if increased improvement is found desirable.

Continuing Improvement Program

As presently envisioned, the staging shown on Table X-12 is preferable in combination with the proposed Phase I. Figure X-2 shows the configuration of the entire recommended program. The range of costs of these facilities shown on Table X-12 are completely dependent on levels of control selected for subsequent phases. The cost ranges presented are for levels of control considered by the City. It is entirely possible that the final sizing or some facilities may result in costs outside these ranges. Again, cost-effectiveness analyses must be used to determine the sizing the therefore the cost and degree of control of facilities in subsequent construction phases.

Table X-1

TABLE X-1: STAGING AS PRESENTED IN MASTER PLAN REPORT

ALTERNATE MP
PRESENT WORTH $550 MILLION
PREPARATION PERIOD - 2 YEARS

PHASE	ELEMENT	DESCRIPTION		ESTIMATED COSTS (1974 DOLLARS) PROJECT COST (10^6\$)	O & M COSTS (10^6\$/yr)	GOALS ATTAINED
		Existing facilities:	R-S	0	0.99 (1)	
			SE	0	1.25 (2)	
			NP	0	2.09 (3)	
1	1	Storage-Marina and North Beach areas (retention basins) (stage 1)		16.1	0.029	6
2	1	Transport system Richmond-Sunset to Lake Merced (WW Capacity)		40.2	0.06	
	2	FM's, PS's and conduits Ocean side	FM	13.4		
		(stage 3)	PS	8.2	0.059	
	3	WW Ocean outfall (1000 mgd peak) (stage 2)		30.0	0.01	7
3	1	North Ocean side storage (stage 4)		10.8	0.019	
	2	Southwest STP (level 1) (325 mgd peak) (stage 5)		55.5	1.33	
	3	Central Ocean side storage (stage 6)		36.7	0.064	
	4	East-West section of crosstown tunnel (including storage) (stages 7 and 9)		47.7	0.07	11
4	1	Expand Southwest STP to 550 mgd peak level 1		35.3	0.92	
	2	Upgrade Southwest STP to 250 mgd peak level II		64.0	4.82	
	3	Pump stations, FM's, conduits central	FM & C	30.0		
		eastern area (stage 13)	PS	26.2	0.152	
	4	Storage central eastern area (stage 13)		50.9	0.089	8
	5	DW extension to WW outfall		14.4	0.01	
	6	PS Southeast STP to tunnel for DW flow	PS	(included in 4-3)	0.098	
5	1	North-South section of crosstown tunnel (storage included) (stages 11,14)		44.7	0.06	12
6	1	Expand level I STP to 820 mgd peak (stage 15)		41.3	0.42	
	2	PS, FM, conduits Northeast area	FM & C	24.8	0	
		(part stage 16)	PS	21.3	0.106	
	3	PS, FM, North Point to tunnel for DW flow	FM PS	(included in 6-2)	0.315	1-5, 5a, 10
7	1	Expand Southwest STP level I to 1000 mgd peak (part stage 16)		26.9	0.27	9
8	1	Bypass outfall consolidation		24.5	0	

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(1) Until Phase 3 complete
(2) Until Phase 4 complete
(3) Until Phase 6 complete

Note: FM = Force Main
PS = Pump Station
C = Conduits
WW = Wet Weather (Facilities for combined stormwater runoff and domestic and industrial wastewaters)
DW = Dry Weather (Facilities for domestic & industrial wastewater only)
O&M = Operation and Maintenance

Table X-2

TABLE X-2: MASTER PLAN FACILITIES WITH EMPHASIS ON EARLY DRY WEATHER CONTROL

ALTERNATIVE MP-1
PRESENT WORTH $565 MILLION
PREPARATION PERIOD - 2 YEARS

					Estimated Costs (1974 dollars)		
PHASE	ELEMENT	DESCRIPTION			Project Cost $(10^6\ \$)$	O & M COSTS $(10^6\$/yr)$	GOALS ATTAINED
		Existing facilities	NP		0	2.09 (1)	
			SE		0	1.25 (1)	
			R-S		0	0.99 (1)	
1	1	Crosstown tunnel (no storage)			53.1	0.13	
	2	FM and PS from North Point STP		FM	4.2		
		to tunnel (200 mgd peak)		PS	5.5	0.32	
	3	FM and PS from Southeast STP to		FM	2.8		
		tunnel (70 mgd peak)		PS	3.2	0.10	
	4	Combined WW and DW Ocean Outfall (1000 mgd peak)			44.4	0.02	5
	5	FM and PS Marina Outfall to		FM	4.6		
		North Point STP		PS	5.2	0.02	1,2,3
2	1	Southwest STP (level II) (250 mgd peak)			111.0	6.62	
	2	Operate North Point STP as WW facility			0	0.63 (2)	
	3	Transport system - Ocean side interceptor			40.2	0.06	4,5a
3	1	WW PS's, FM's and conduits	NP area	FM & C	16.0		
				PS	10.6	0.065	6
			Ocean side	FM & C	13.4		
				PS	8.2	0.059	7
			SE area	FM & C	28.7		
				PS	23.3	0.152	8
4	1	Expand Southwest level I to 1000 mgd peak			100.0	1.14	9
5	1	North area storage (including tunnel)			52.1	0.068	10
6	1	Ocean side storage (including tunnel)			54.9	0.071	11
7	1	Southeast area storage (including tunnel)			46.9	0.061	12
8	1	Bypass outfall consolidation			24.5	0	

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(1) Until Phase 2 complete
(2) Until Phase 4 complete

Table X-3

TABLE X-3: MASTER PLAN FACILITIES WITH EARLY EMPHASIS ON DRY WEATHER CONTROL AND UPSTREAM BASIN STORAGE IN NORTH POINT AND SOUTHEAST AREAS TRANSFERRED TO TUNNEL

ALTERNATIVE MP-2
PRESENT WORTH $520 MILLION
PREPARATION PERIOD - 3 YEARS

				Estimated Costs (1974 dollars)		
PHASE	ELEMENT	DESCRIPTION		Project Cost (10^6 $)	O & M COSTS (10^6\$/yr)	GOALS ATTAINED
		Existing facilities	ALL	0	4.33 (1)	
1	1	Conduits connected to tunnel		22.6	0	
	2	Crosstown tunnel (with storage = Alt B in tributary upstream basins in tunnel storage)	SE & NP (only)	85.3	0.13	
	3	FM and PS for North Point to tunnel	FM	4.2		
		(200 mgd peak)	PS	5.5	0.32	
	4	FM and PS for Southeast to tunnel	FM	2.8		
		(70 mgd peak)	PS	3.2	0.10	
	5	Ocean outfall at Southwest (WW & DW)		44.4	0.002	5
	6	FM and PS Marina outfall to North Point	FM	4.6		
		STP	PS	5.2	0.02	1,2,3
2	1	Southwest level II STP (250 mgd peak)		111.0	6.62	
	2	Transport system - Richmond-Sunset to Southwest		40.2	0.06	
	3	Operate North Point as WW facility		0	0.63 (2)	4,5a,6
3	1	North Point area FM, PS and conduit	FM & C	9.3		
		(not in Phase I)	PS	10.6	0.065	10
4	1	Ocean side FM, PS and conduits	FM & C	13.4		
			PS	8.2	0.059	7
5	1	Southeast area FM, PS and Conduits	FM & C	12.7		
		(not in Phase I)	PS	23.3	0.152	8
6	1	Expand Southwest STP level I to 1000 mgd max		100.0	1.14	9
7	1	Ocean side upstream retention basins		33.4	0.05	11
8	1	Shoreline retention basins		66.3	0.10	12
9	1	Bypass outfall consolidation		24.5	0	

(1) Until Phase 2 complete
(2) Until Phase 6 complete

Table X-4

TABLE X-4: ENTIRE DRY WEATHER PROJECT THEN WET WEATHER CONTROL FACILITIES

ALTERNATIVE DW
PRESENT WORTH $655 MILLION
PREPARATION PERIOD - 1 YEAR

				Estimated Costs (1974 dollars)		
PHASE	ELEMENT	DESCRIPTION		Project Cost $(10^{6}\ \$)$	O & M COSTS $(10^{6}\$/yr)$	GOALS ATTAINED
		Existing facilities NP & SE		0	3.34 (1)	
		R-S		0	0.99 (2)	
1	1	FM and PS for DW flow North Point to Southeast (200 mgd peak)	FM	23.5	0.3	
	2	Expand and upgrade Southeast STP to level II (100 mgd DADWF)		91.0	6.07	
	3	Operate North Point as WW STP until Lake Merced WW plant operational		0	0.63 (3)	
	4	FM and PS Marina outfall to North Point STP	FM	4.6		
			PS	5.2	0.02	1,2
2	1	Upgrade Richmond-Sunset to level II		22.0	1.69	4
3	1	Transport line from Southeast STP to Lake Merced (340 mgd peak)		33.5	0.59	
	2	Ocean outfall (410 mgd peak)		25.0	0.01	3,5
4	1	Transport line Richmond-Sunset to Lake Merced (70 mgd peak)		9.0	0	5a
5	1	North area storage (excluding tunnel storage)		36.5	0.068	6
6	1	Ocean area storage (excluding tunnel)		50.1	0.071	7
7	1	Ocean side transport tunnel to Lake Merced		40.2	0.06	
	2	PS, FM, conduits Richmond-Sunset area	FM & C	13.4		
			PS	8.2	0.059	
	3	Ocean outfall (1000 mgd max)		30.0	0.01	11
8	1	East side storage (retention basins only)		29.3	0.061	8
9	1	Southwest STP (level I) (1000 mgd max)		127.2	1.19	9
10	1	Crosstown tunnel (including storage)		91.1	0.13	
	2	FM, PS, conduits North Point and Southeast areas	FM & C	50.2		
			PS	42.4	0.238	10,12
11	1	Bypass outfall consolidation		24.5	0	

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(1) Until Phase 1 complete
(2) Until Phase 2 complete
(3) Until Phase 9 complete

Note: DADWF = Design Average Dry Weather Flow

Table X-5

TABLE X-5: INTERIM IMPROVEMENTS AT NORTH POINT AND SOUTHEAST THEN IMPLEMENTATION OF MASTER PLAN FACILITIES WITH EARLY EMPHASIS ON DRY WEATHER CONTROL

ALTERNATIVE DW-1
PRESENT WORTH $590 MILLION
PREPARATION PERIOD - 1 YEAR

				Estimated Costs (1974 dollars)		
PHASE	ELEMENT	DESCRIPTION		Project Cost $(10^6\ \$)$	O & M COSTS $(10^6\ \$/yr)$	GOALS ATTAINED
		Existing facilities SE		0	1.25 (1)	
		NP & R-S		0	3.08 (2)	
1	1	Improved North Point outfall		9.0	0.01 (3)	
	2	Upgrade Southeast to secondary level (20 mgd mean)		22.0	1.91 (2)	1
2	1	Crosstown tunnel (no storage)		53.1	0.13	
	2	FM and PS for North Point to tunnel	FM	4.2		
		(200 mgd peak)	PS	5.5	0.32	
	3	FM and PS for Southeast to tunnel	FM	2.8		
		(70 mgd peak)	PS	3.2	0.10	
	4	Ocean outfall (WW-DW) (750 mgd peak WW) (250 mgd Peak DW)		44.4	0.002	
	5	FM and PS Marina outfall to North Point	FM	4.6		
		STP	PS	5.2	0.02	2,3,5
3	1	Southwest STP (level II) (125 mgd DADWF) (250 mgd peak)		111.0	6.62	
	2	Operate North Point STP as WW facility		0	0.63 (4)	
	3	Transport system - Richmond-Sunset to Lake Merced		40.2	0.06	4,5a
4	1	Wet Weather PS, FM and conduits				
		NP area	FM	16.0		
			PS	10.6	0.065	6
		Ocean side	FM	13.4		
			PS	8.2	0.059	7
		SE area	FM	28.7		
			PS	23.3	0.152	8
5	1	Expand Southwest STP level I to 100 mgd max		100.0	1.14	9
6	1	North area storage (including tunnel storage)		52.1	0.068	10
7	1	Ocean side storage (including tunnel storage)		54.9	0.071	11
8	1	Southeast area storage (including tunnel storage)		46.9	0.061	12
9	1	Bypass outfall consolidation		24.5	0	

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(1) Until Phase 1 complete
(2) Until Phase 3 complete
(3) Until Phase 5 complete
(4) Until Phase 6 complete

Table X-6

TABLE X-6: DRY WEATHER PROJECT PHASE I THEN WET WEATHER CONTROL FACILITIES

ALTERNATIVE DW-2
PRESENT WORTH $615 MILLION
PREPARATION PERIOD - 1 YEAR

PHASE	ELEMENT	DESCRIPTION		Estimated Costs (1974 dollars) Project Cost (10^6 $)	O & M COSTS ($10^6$$/yr)	GOALS ATTAINED
		Existing facilities NP & SE		0	3.34 (1)	
		R-S		0	0.99 (2)	
1	1	DW transport line North Point to Southeast (200 mgd peak)	FM	23.5	0.30	
	2	Expand and upgrade Southeast STP (level II) (100 mgd DADWF)		91.0	6.07	
	3	Operate North Point as WW until Southwest STP WW		0	0.63 (3)	
	4	FM and PS Marina outfall to North Point STP	FM	4.6	0	
			PS	5.2	0.02	1,2
2	1	Upgrade Richmond-Sunset to level II		22.0	1.69	4
3	1	North area storage (excluding tunnel)		36.5	0.054	6
4	1	Ocean side interceptor		40.2	0.06	
	2	Ocean side WW PS, FM and conduits	FM & C	13.4		
			PS	8.2	0.059	
	3	Ocean outfall (WW) (1000 mgd peak)		30.0	0.01	7
5	1	East-west section of crosstown tunnel (no storage)		28.2	0.06	
	2	FM and PS Southeast to tunnel (100 mgd DADWF)	FM	3.9		
			PS	8.9	0.45	3,5
6	1	FM, PS and conduits Southeast area	FM & C	26.1		
			PS	17.3	0.113	8
7	1	Ocean outfall (DW extension) (250 mgd peak)		14.4	0.001	5a
8	1	Ocean area storage (including tunnel)		54.9	0.082	11
9	1	Southwest WW STP (1000 mgd) (level)		127.2	1.19	
	2	North-south section of crosstown tunnel (including storage)		44.7	0.07	
	3	PS, FM, conduits for North Point area	FM & C	20.2		
			PS	16.1	0.106	9,10
10	1	East area storage (including tunnel not in 9)		42.9	0.064	12
11	1	Bypass outfall consolidation		24.5	0	

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(1) Until Phase 1 complete
(2) Until Phase 2 complete
(3) Until Phase 9 complete

Table X-7

TABLE X-7: DRY WEATHER PROJECT PHASE I WITH MASTER PLAN TUNNEL IN PLACE OF PROJECT TRANSPORT LINE THEN WET WEATHER CONTROL FACILITIES

ALTERNATIVE DW-3
PRESENT WORTH $615 MILLION
PREPARATION PERIOD - 2 YEARS

PHASE	ELEMENT	DESCRIPTION		Estimated Costs (1974 dollars) Project Cost (10^6 $)	O & M COSTS (10^6\$/yr)	GOALS ATTAINED
		Existing facilities	NP & SE	0	3.34 (1)	
			R-S	0	0.99 (2)	
1	1	North-south section of crosstown tunnel (no storage)		24.9	0.06	
	2	FM, PS for North Point to tunnel	FM	4.2		
		(200 mgd peak)	PS	5.5	0.32	
	3	FM only for tunnel to Southeast	FM	2.6	0	
	4	Expand and upgrade Southeast STP (level II) (100 mgd DADWF)		91.0	6.07	
	5	Operate North Point as WW STP until Southwest WW STP		0	0.63 (3)	
	6	FM and PS Marina outfall to North	FM	4.6		
		Point STP	PS	5.2	0.02	1,2
2	1	Upgrade Richmond-Sunset STP to Level II			1.69	4
3	1	East-west section of crosstown tunnel (no storage)		28.2	0.07	
	2	FM and PS to pump Southeast effluent to	FM	3.9		
		tunnel (100 mgd DADWF)	PS	8.9	0.45	
	3	Ocean outfall (250 mgd peak DW) (1000 mgd peak WW)		44.4	0.002	3,5
4	1	Ocean side transport sewer (WW capacity)		40.2	0.06	
	2	Ocean side FM's, PS's and conduits	FM & C	13.4		
			PS	8.2	0.059	5a,7
5	1	FM's, PS's, conduits North Point and	FM & C	42.1		
		Southeast areas not in phases 1 and 3	PS	27.9	0.17	6,8
6	1	Southwest WW STP (level I) (1000 mgd max)		127.2	1.19	9
7	1	North area storage (including tunnel)		52.1	0.068	10
8	1	Ocean side storage (including tunnel)		54.9	0.071	11
9	1	East side storage (including tunnel)		46.9	0.061	12
10	1	Bypass outfall consolidation		24.5	0	

(1) Until Phase 1 complete
(2) Until Phase 2 complete
(3) Until Phase 6 complete

Table X-8

TABLE X-8: PHASE I OF DRY WEATHER PROJECT WITH LOCAL WET WEATHER TREATMENT AND DISPOSAL

ALTERNATIVE C
PRESENT WORTH $620 MILLION
PREPARATION PERIOD - 1 YEAR

				Estimated Costs (1974 dollars)		
PHASE	ELEMENT	DESCRIPTION		Project Cost $(10^6\ \$)$	O & M COSTS $(10^6\$/yr)$	GOALS ATTAINED
		Existing facilities SE & NP		0	3.34 (1)	
		R-S		0	0.99 (2)	
1	1	DW project FM North Point to Southeast (200 mgd peak)	FM	23.5	0.3	
	2	Expand and upgrade Southeast to (100 mgd DADWF level II)		91.0	6.07	
	3	Operate North Point STP as WW facility		0	0.63 (3)	
	4	PS and FM Marina outfall to North Point	FM	4.6		
		STP	PS	5.2	0.02	1,2
2	1.	Upgrade Richmond-Sunset to level II (70 mgd peak) (20 mgd DADWS)		22.0	1.69	4
3	1	North area storage (Alt C storage-all retention basins)		90.0	0.096	6,10
4	1	Ocean side storage (Alt C storage-all retention basins)		106.8	0.114	
		Ocean outfall for Richmond-Sunset (1000 mgd peak WW) (250 mgd peak DW)		14.5	0.01	7
5	1	Southeast area storage (Alt C storage-all retention basins)		84.6	0.09	8
6	1	Expand Southeast STP level I to 500 mgd peak		39.3	0.47	
	2	Lengthen and enlarge Southeast outfall		14.5	0.01	
	3	Expand Richmond-Sunset STP level I to 500 mgd peak		63.0	0.38	9
7	1	FM, PS and conduits for entire city	FM & C	55.5		
		(except North Point and Southeast to tunnel and Marina)	PS	36.1	0.32	11,12
8	1	Bypass outfall consolidation		24.5	0	

(1) Until Phase 1 complete
(2) Until Phase 2 complete
(3) Until Phase 6 complete

Table X-9

RECOMMENDED PHASE I FACILITIES

Facility Description	Estimated Capital Cost (10^6\$)
Expand and Upgrade Southeast WPCP	92
Improve Southeast Outfall	7
Upgrade Richmond-Sunset WPCP	13
Retention Basins	
Alt. A stro storage	
21-1, 21-4, 28-1	4.6
Alt. B storage	
21-1, 24-1	7
Pump Stations (to control runoff from 0.3 in/hr of rain)	
@ 21-1	3
@ 24-1	2
@ 28-1	2
Force Mains, conduits and tunnels	
21-1 to NPWPCP (3 FM's)	4.7
24-1 to NPWPCP (FM)	2
28-1 to NPWPCP (3 FM's)	0.5
Bypass Consolidation @ 21-1	2
Bypass Consolidation @ 24-1	2.5
Bypass Consolidation @ 28-1	5
Conduits @ 21-2 and 21, 4	1
NPWPCP to SEWPCP (Including pump station)	24
RSWPCP to Lake Merced	25
Miscellaneous connections and changes @ NPWPCP	2
Ocean Outfall @ Lake Merced	30
Total	229.3

(1) Includes Pump Station

Table X-10

RECOMMENDED PHASE I TREATMENT FACILITIES

Treatment Plant	Type	Treatment	Design Flow
Southeast	Dry weather with wet weather capacity	Secondary Chemical	100 MGD mean
Richmond-Sunset	Dry weather with wet weather capacity	Primary with Chemical Addition and Rapid Sand Filtration	25 MGD mean 70 MGD peak
North Point	Wet Weather Only	Primary or Primary with Chemical addition	190 MGD peak

Table X-11

PHASE I STORAGE AND CONTROL

Drainage Basin No.	Retention Basin No.	Storage Alternative (1)	Storage Volume (Million cubic feet)	Estimated Bypass (2) Frequency (3) (no/yr)	Estimated Bypass (2) Volume (4) (MG/yr)
21	1	B	0.37	3	10
	2	A	0.10		
	4	A	0.12		
24	1	B	0.28	4	7
28	1	A	0.20	5	8

(1) As defined in the Master Plan Report (Ref.1)
(2) Assumes a uniform treatment rate - these values can be varied by directing a greater part of the treatment capacity at a specific drainage area.
(3) From Figure VI-2
(4) From Figure VI-3

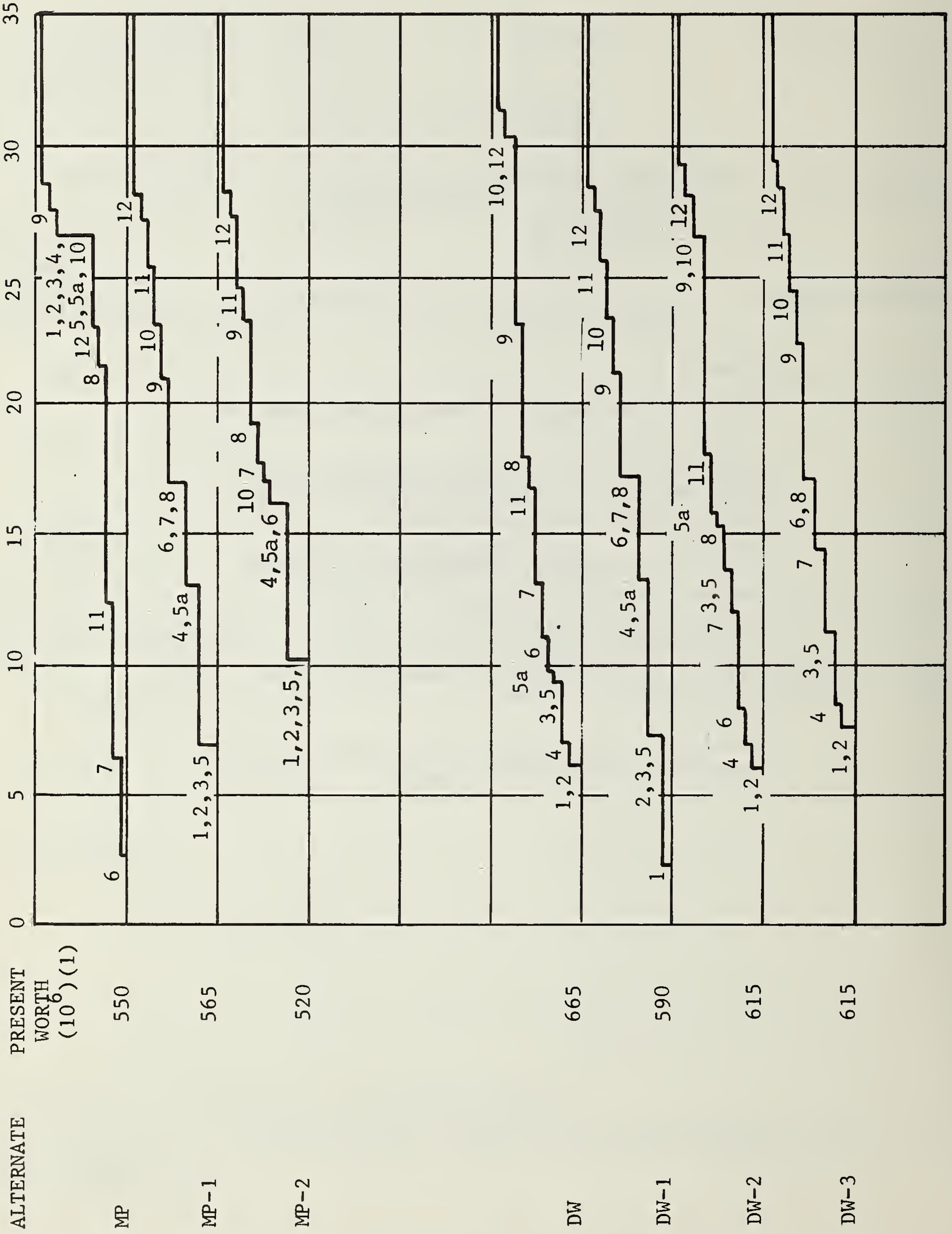
Table X-12

TOTAL PROGRAM FACILITIES AND COSTS

Phase	Facility Description	Capital Cost Range (10^6\$)
1	Phase I	229
2	Oceanside wet weather transport and shoreline storage facilities	38.1-69.0
3	Pipeline and tunnel southest Southeast to Lake Merced and adjacent upstream storage	65.9-111.6
	Ocean outfall extension	15.0
4	Southeast wet weather transport facilities	10.6-28.1
5	Oceanside upstream storage facilities	13.9-90.7
6	Lake Merced Treatment Plant	127
7	Pipeline and tunnel from North Point area with upstream storage	34.7-117.5
	Remainder of storage and transport facilities North Point and Southeast areas	62.9-193.2
		597.1-981.1

Figure X-1

COMPARISON OF ATTAINMENT GOAL FOR ALTERNATE PLANS
Years to attain goals at 25 M $/year capital expenditure



(1) Present worth calculations based on $25 million per year capital expenditures

Figure X-2

RECOMMENDED PROGRAM FACILITIES

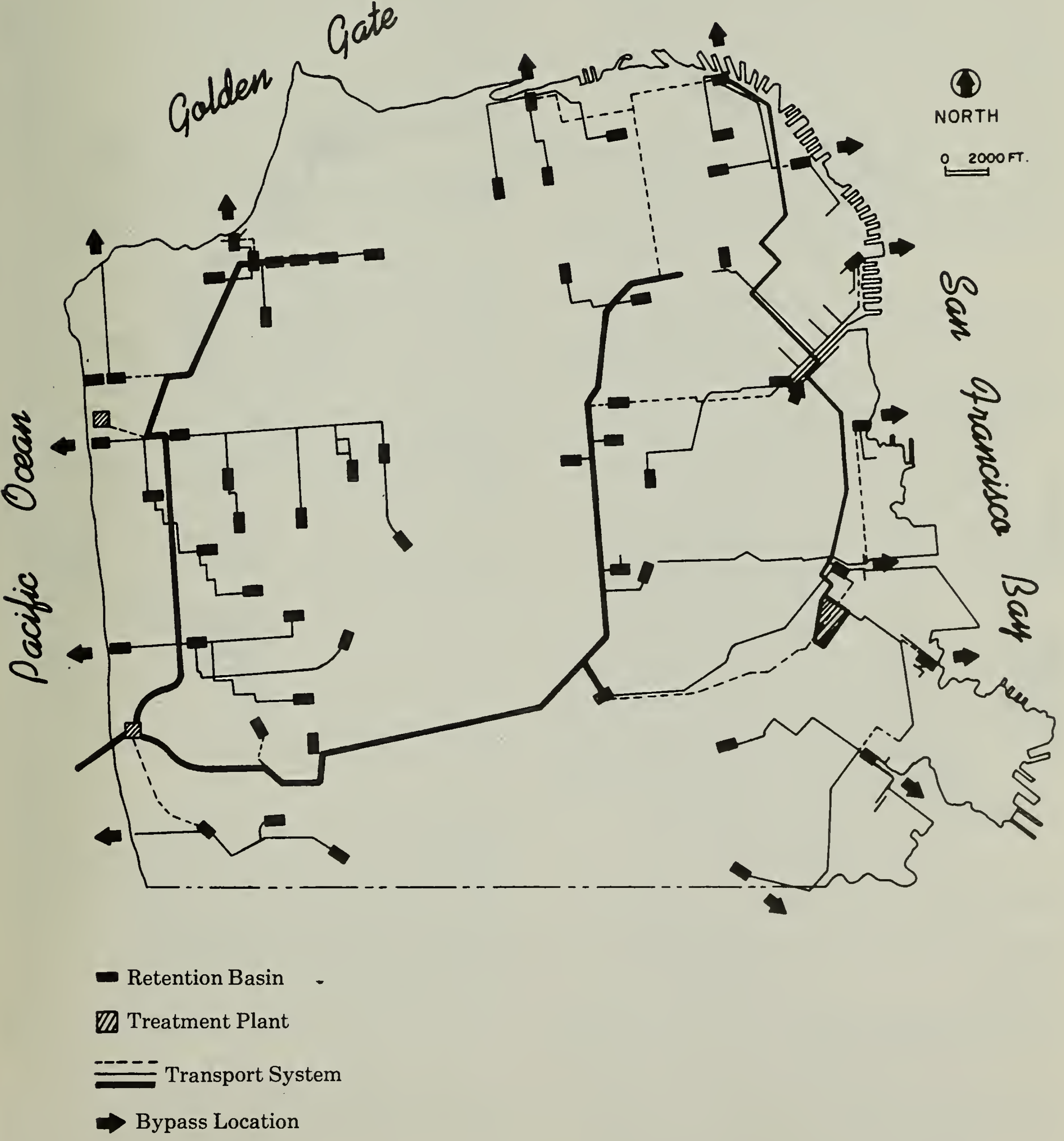
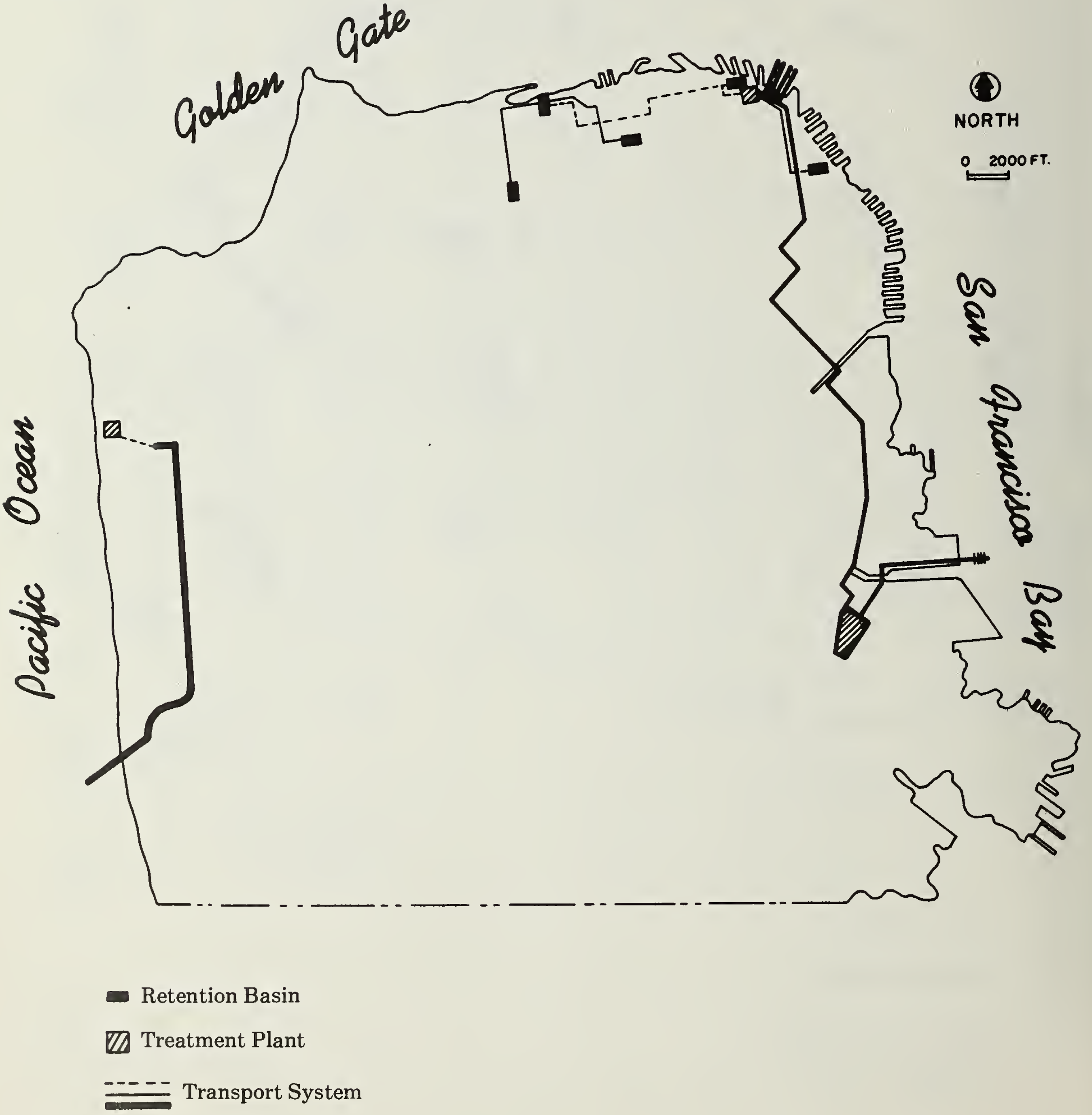


Figure X-3

RECOMMENDED FIRST PHASE FACILITIES



Chapter XI

FINANCIAL FEASIBILITY

To properly evaluate the financial aspects of the Master Plan Report it is necessary to consider the data and fiscal tools that are available to the City. It is also necessary to consider the future availability of financial assistance, the alternatives for local funding, and the effect of the financial assumptions on program implementation. The basic questions that must be answered are:

- Is the proposed program and its various alternative elements the most efficient from a cost/ benefit standpoint?
- Is the proposed financial plan the best way for the City to plan for paying the program costs?
- What data and assumptions have formed the basis for the financing approach?
- What additional information is necessary?

Every assumption in the Master Plan has a direct or indirect financial implication. Because of the program length (20-30 years) and its cost ($400-950 million) predictions regarding future policy decisions become very significant. The more important of these include:

- The availability of State and Federal financial assistance.
- Federal and State policies regarding priority of pollution control needs.
- The future demand for other public projects in San Francisco.
- The relative importance that society will continue to assign to wastewater control projects.

The basic design criteria are: minimizing the contamination of beaches, improving the aesthetics of water surface, and achieving acceptable levels of pollutant reduction for dry weather flows. Policy determination as to the balance between investment and environmental improvement become predominant. In making these basic policy decisions, the precision of cost estimating is less important than relative differences between alternatives in costs and achievements.

The policy of the San Francisco Board of Supervisors expressed in Resolution 558-69 has served as a basic tenant to the development of the Master Plan and is as follows:

> "RESOLVED, That the Board of Supervisors expresses its willingness to explore and pursue, independently and in cooperation with appropriate regional agencies, all economically feasible methods of meeting applicable Federal and State water quality requirements and standards, including the regional concept expressed in the Bay-Delta Report and local treatment and disposal alternatives, in order to provide for water quality meeting all applicable standards at the lowest cost to the residents of San Francisco."

PROPOSED FINANCING PLAN

The financing plan recommended in the Master Plan Report considers:

- Increasing maintenance and operation costs.
- The speed of implementation as related to the availability of Federal and State funds.
- A cost benefit relationship to determine the degree of control of wet weather flows.
- A "building block" concept related to changing water requirements which will assure that each investment as well as the total plan maximizes the benefit/cost relationship.

The Report recommendation is that the City submit a cash flow program of possible bond issues for alternative overflow schemes which will reflect the City's portion of the cost allocated from the total wastewater management program. And further that upon determination of certain variables a bond election be scheduled. These variables are:

- Total program cost (dependent on the degree of wet weather control).
- Costs of various program stages.
- The time period for completion of the program stages.
- Federal and State grant programs and available assistance.

The following assumptions were utilized in development of the proposed financing plan as presented in Chapter IX of the Master Plan Report:

- Cost estimates are in 1974 dollars.
- Grants at 80 percent of project costs; but if this level is not available, the time for full implementation would be extended.

- Repayment of the City's bond issues are based on 15-year redemption period at 6 percent interest.
- All major capital costs are included in the program including sewer line construction, treatment facilities, transportation facilities, and wet weather facilities.
- For purposes of estimating future major bond sales, 6 percent escalation was assumed.
- The closer the sum of outstanding bonds to the debt limit, the higher the interest rate will be on new bond sales.
- It is not desirable to use the full bonding capacity of the City.
- Sewer service charges will be adjusted to provide sufficient funds to pay operation and maintenance expenses and to amortize presently authorized water pollution control bonds.
- Bonds that would be needed in addition to those existing will be subject to the 12 percent limitation.
- The bond sale authorization will be presented to the voters in blocks every five to seven years.
- The program could not be built in less than 20 years due to time requirements of design, financing, and construction and 30 years is the longest time that should be considered.
- Capital cost expenditures for parts of the project will be made in uniform annual increments.
- Building upstream storage retention basins will reduce the cost of sewer replacement from $150 to $100 million.
- Replacement of brick and small sewers will result in an annual expenditure of $3.75 million.

Wet weather control, dry weather costs, replacement of inadequate sewers, and replacement of small and deteriorating sewers constitute the four elements of costs creating the cash flow requirements of the program.

METHODS OF FINANCING

Possible funding sources are City funds and State and Federal grants. Local funding would be based upon ad valorem or tax charges, user charges, and bonds.

Local Funding

The Report rejects "pay-as-you-go financing" in favor of long-term obligations for major capital expenditures and recommends general obligation bonds. Capital available from bonds already issued is currently $71 million. The Plan indicates these funds will not be adequate to meet the program needs. The City's charter limits outstanding bonds to 12 percent of the City's assessed valuation **except** for bonds which are serviced by revenues from the sewer service charge. Table XI-1 summarizes the City's recent bond debt history.

The assumption of a 6 percent bond interest rate used in the Master Plan Report finance discussion is conservative when considering the range of interest rates actually being paid by the City. All City interest rates have been under 5 percent even under adverse market conditions. In addition, there appears to be little correlation between actual interest rates experienced and the ratio of outstanding bonds to the City's bond debt limit. Additional flexibility would be provided by assuming that revenue financing sewer bonds would not be subject to the 12 percent limitation.

A 15-year maturity schedule as proposed is about as short as any municipality uses. It is true that the interest rate will be reduced, but repayment is higher; thus users of the system which will last for many years, as long as 80 years for some facilities, will be paying 15 years for about 50 years of benefits. A bond maturity range from 20 to 30 years for sanitary facilities is common and in some cases water facilities have been financed with bonds with maturities up to 40 years. For the same interest rate an increase in the term of repayment from 15 to 30 years would result in a 30 percent reduction in the annual repayment costs.

If the City can demonstrate its ability to finance this system with its traditional approach to long-term debt, there will be little problem with the regulatory agencies. However, if these assumptions result in policy decisions which delay compliance, particularly when the common practice in other municipalities is different, it will be necessary for additional data to be developed to support the approach presently assumed.

Sewer replacements and additions are currently financed by issuance of municipal bonds. An estimated $150 million will be required over thirty years to replace inadequate sewers and thereby control street flooding. This cost would be reduced by up to $50 million with construction of Master Plan upstream retention basins. The City currently has a program of replacing and adding sewers at a rate of $7 million per year, approximately half of which is for control of street flooding. Funds are currently available to support the program until mid-1978. An additional portion of the currently available funds are budgeted for bypass outfall consolidation which is a portion of the Master Plan program.

Sewer service charges and ad valorem taxes are the prime sources of funds for repayment of bond indebtedness. Current user charges generate $13.5 million annually. Funds available from ad valorem taxes are dependent on the relative needs of other local finance projects and services.

Grant Availability

Table XI-2 summarizes the ranges of availability of financial assistance for various elements of project cost. Due to fund shortages, the regulatory agencies have established priorities which are oriented toward achieving the greatest water quality improvement for the least investment of grant funds. Thus, it can be expected that funds will not be made available for culvert and catchbasin construction and for the replacement of sewers in the foreseeable future. It is assumed that the side sewers referred to in the table are those project items which are described in the Master Plan Report as costing between $100 and $150 million depending upon the number and size of the wet weather Master Plan storage basins. Further discussion of grant availability under the recent Federal Water Pollution Control Act and State law amendments is included in Chapter V of this report. Table XI-3 compares two possible program costs ($570 and $690 million) under various combinations of local-and grant-aided funding showing the range of annual cost under various financing alternatives.

EVALUATION

Data presented in the Master Plan is sufficient to provide a basis for decisions on project scope, timing, and concepts. It will be necessary to develop additional data on:

- Maintenance and operation costs.
- The advantages of using longer term bonds.
- An analysis of the program for sale of the outstanding but unsold bonds.
- An estimate of total present and projected revenues from sewer service charges, taxes, or other fees.
- Past and projected incremental operating costs.
- The comparison of current status of revenue bond rates with rates for general obligation bonds.
- The future total capital needs of the City and anticipated sources of revenue.
- The funding levels required for various project configurations integrating dry weather facilities as well as separable facilities, with consideration to Public Law 92-500 and forthcoming cost-effectiveness guidelines.

An attempt was made to compare the cost of San Francisco's future wastewater program to that of other communities on a cost per capita per year basis and cost per year per $100 assessed valuation. The costs should be based on achieving similar standards and should consider stormwater management costs as well as sewage disposal facilities.

Even with inclusion of these factors there would be several inequities in such a comparison that would limit its usefulness. San Francisco has realized a considerable savings by not constructing and operating a separate storm drain system. By constructing the proposed facilities, San Francisco would realize certain benefits in flood protection associated with the storage capacity of the system. This same protection may not exist in other communities or that benefit may be provided at the expense of the State or Federal Government.

The differences between communities make it quite difficult to develop the cost comparison. In general it can be said that cost per residence per month for wastewater service is averaging between $5 and $10 for new wastewater systems being proposed in northern California. While the Master Plan costs will run higher than this amount, perhaps as much as $20 per month without Federal grants, present costs of other utility services are frequently in this range, and a significant amount of grant funds is virtually assured.

CONCLUSIONS

The City's financial plan is a feasible method for implementation of the Master Plan but is based upon a series of assumptions that should be reviewed prior to the approval of a short- or long-term financing program.

New State and Federal laws provide for grants as high as 87½ percent. Federal law provides for cost-effective analysis which may result in a high priority status for portions, if not all, of the Master Plan.

Repayment requirements in Federal legislation, particularly relating to industrial repayments, should be compared with State requirements to determine if the City's sources of revenue are adequate. Both the Environmental Protection Agency and the State Water Resources Control Board will issue new regulations shortly.

The cost-effectiveness of wet weather elements should be studied to determine appropriate staging, and alternatives should be tested against financing plans to determine the one that best fits the City's long-range overall needs.

State and Federal grant requirements regarding reserves and repayment are only part of the criteria for establishing a rate structure and bond sale program. Other basic factors include distribution of costs to future beneficiaries, completion of operable phases of the wet weather master plan, and project development to take maximum advantage of future funding that may become available.

The basic concept of paying for operation and maintenance costs from service charges (presently about $13 million per year) and the local repayment on bonds sold to finance the local (12½ percent) share of project capital costs, on property tax assessments, should be reassessed in the light of San Francisco's very large transient population, both tourist and business, as well as the ratio of industrial assessed valuation to industrial waste loading.

The financing portion of the Master Plan and the revenue program of December 1972 should be integrated into a short- and long-term program that complies with regulatory requirements and reflects the results of cost-effectiveness analysis and alternate financial assumptions.

The cost of implementing the Master Plan without financial assistance is quite high — under the worst set of alternatives regarding grant assistance and timing, as much as $50 per capita per year. With careful staging and the availability of grant funds, this cost could drop to as low as $10 per capita per year.

It is not desirable to adopt either the Master Plan or the financing plan in detail for the total project. The basic principles of cost, repayment, and sharing should be determined within the next year, but the actual details of rate schedules, bond sales, and grant procurement should be developed for each stage of the Master Plan.

RECOMMENDED PHASE I FINANCING

In the preceding chapter a recommended first construction phase for implementing the Master Plan concept was developed. It is recommended that the following financing program be initiated to fund this phase:

- Existing but unsold City bonds should be used to finance the local share (12½ percent) and provide working capital for the construction of the Phase I project.
- Bonds should be sold to achieve long-term repayment and to anticipate future costs if grants should be less than anticipated.
- A comprehensive revenue program should be prepared reflecting current changes in State and Federal regulations to establish long-term principles of financing and detail a specific short-term program for implementaton of Phase I.

Table XI-1

SAN FRANCISCO BOND SALE HISTORY

Sale Date	Sale Amount	Net Interest Cost on 15-year Term Bonds	Coupon Range	Re-offering Prices	
				10-year Maturity	15-year Maturity
6/12/61	$11,275,000	2.99	2½-5	2.90	3.20
2/13/62	27,300,000	2.73	2¼-4	2.65	2.90
3/18/63	37,215,000	2.51	2 -5	-	-
8/10/64	15,810,000	-	¼ -6	2.85	3.00
8/16/65	12,690,000	2.97	2-3/4-3	3.00	3.10
9/26/66	25,620,000	4.30	4 -6	3.90	3.90
8/1/67	45,000,000	3.84(20 yr)	3.7-5	-	-
4/1/68	31,815,000	4.06	3.9-5.4	4.05	4.10
1/27/69	30,700,000	4.44	-	-	-
1/12/70	45,800,000	-	3½-5	4.10	4.60
12/14/70	52,960,000	4.21	3.3-4.8	3.90	4.50
1/10/72	37,000,000	3.97	-	-	-

1971-72 Assessed Valuation: $2,348,225,304
1972-73 Assessed Valuation: $2,434,349,685

Table XI-2

	Funding Sources	Wet Weather Construction (Treatment Plant, Tunnels, Basins and Transport to Plant)	Dry Weather Construction (Treatment Plant and Transport to Plant)	Outfall	Side Sewers	Culverts and Catchbasin Construction	Replacement of Sewers
1A.	City of San Francisco	12½% to 100%(1)	12½% to 100%(1)	12½% to 100%(1)	100%(2)	0% to 100%(3)	100%
2.	State Grants	0% to 12½%	0% to 12½%	0% to 12½%	0%	0% to 12½%	0% to 12½%
3.	Federal Grants	0% to 75%	75%	0% to 75%	0%	0% to 75%	0% to 75%

(1) Property owners pay through Ad-Valorem tax (or use-charge when applicable).
(2) Cost paid by benefitted property owner.
(3) Initial cost paid by benefitted property owner.

Reference 2-Plate IX-1

Table XI-3

Average Costs Per Year
at 7th and 15th Year of 15 Year
Construction Program

Year After Construction Start	Alternate I(1)		Alternate II(2)	
	7th	15th	7th	15th
CASE I				
A. Local Funds - 15 year bonds 6% interest Grant Funds - dry weather only	24	42	29	50
b. Local Funds - 30 year bonds 4.5% interest Grant Funds - Dry weather only	18	28	20	33
CASE II				
a. Local Funds - 15 year bonds 6% interest Grant Funds - dry weather plus 50% wet weather	17	28	20	32
b. Local Funds - 30 year bonds 4.5% interest Grant Funds - all features eligible	13	19	15	22
CASE III				
a. Local Funds - 30 year bonds 4.5% interest Grant Funds - all features religible	9	11	10	12

(1) Total Program Cost = $570 Million
(2) Total Program Cost = $690 Million

ASSUMPTIONS

a. Cases I and II assume no assistance for transport and replacement sewers estimated at $7 million/year.
b. Grants will be 87.5% of eligible costs.
c. Does not include operation and maintenance costs estimated at from $4.5-9 million/year.
d. Alternate I--Scheme I, Alternate A, wet weather control, level two treatment.
e. Alternate II--Scheme III, Alternate B, wet weather control, level two treatment.

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